OCTOBER 1953

Journal

VOL. 45 • NO. 10

AMERICAN WATER WORKS ASSOCIATION

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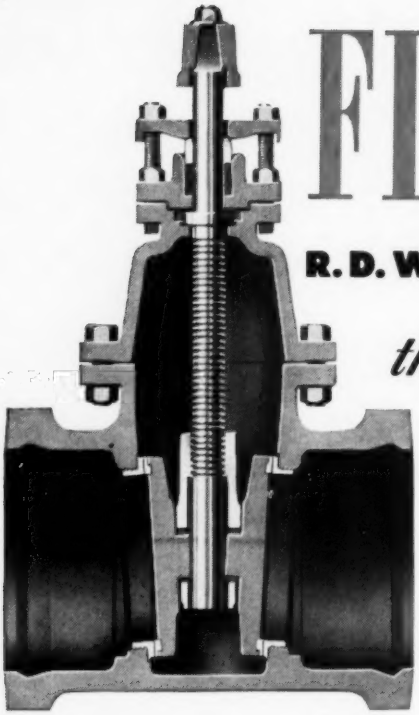

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Vol. 45 • No. 10

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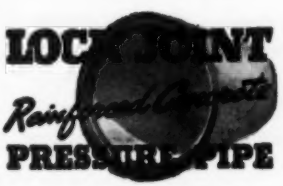

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Oct. 4–6—Alabama-Mississippi Section at Heidelberg Hotel, Jackson, Miss. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Oct. 11–13—Florida Section at McAllister Hotel, Miami. Secretary, William W. Aultman, Asst. Director, Dept. of Water & Sewers, Box 315, Coconut Grove Sta., Miami 33.

Oct. 14–16—Iowa Section at Russell Lamson Hotel, Waterloo. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown.

Oct. 18–21—Southwest Section at Rice Hotel, Houston. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 22–24—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1.

Oct. 27–30—California Section at Palace Hotel, San Francisco. Secretary, John C. Luthin, 1113 Laurent St., Santa Cruz.

Oct. 28–30—Chesapeake Section at Hotel DuPont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., Washington 15, D.C.

Nov. 4–6—Virginia Section at Roanoke Hotel, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Co., Inc., 915 Colonial-American Bank Bldg., Roanoke 11.

Nov. 9–11—North Carolina Section at Hotel Sheraton, High Point. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh.

Dec. 3–5—Cuban Section at Havana. Secretary, L. H. Daniel, Baratillo 9, Havana.

1954 SECTION MEETINGS

Jan. 19—New York, in New York City
Feb. 10–12—Indiana, in Indianapolis
Mar. 17–19—Illinois, in Chicago
Mar. 18—New England, in Boston
Apr. 7–9—Kansas, in Emporia
Apr. 12–14—Canadian, in Toronto, Ont.
Apr. 22–23—Nebraska, in Lincoln
Apr. 22–23—New York, in Watertown
Apr. 22–24—Arizona, in Tucson
Apr. 24–25—Montana, in Bozeman
May 23–28—AWWA, in Seattle
June 16–18—Pennsylvania, in Allentown
Sept. 8–10—New York, in Montauk, L.I.
Sept. 15–17—Michigan, in Muskegon
Sept. 22–24—Ohio, in Dayton
Sept. 28–30—Wisconsin, in Green Bay
Oct. 17–20—Southwest, in El Paso, Tex.
Oct. 26–29—California, in Long Beach
Oct. 27–29—Chesapeake, in Baltimore (Tentative)
Nov. 3–5—Virginia, in Richmond
Nov. 4–6—New Jersey, in Atlantic City

(*Continued on page 10*)

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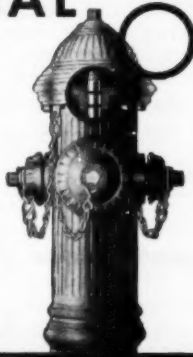

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Coming Meetings

(Continued from page 8)

OTHER ORGANIZATIONS

Oct. 8–9—National Conference on Industrial Hydraulics, Sheraton Hotel, Chicago. Details from Otmar E. Teichman, Conference Director, Illinois Inst. of Technology, 35 W. 33rd St., Chicago 16, Ill.

Oct. 11–12—National Assn. of Vertical Turbine Pump Manufacturers, Broadmoor Hotel, Colorado Springs, Colo. Details from B. A. Tucker, Secy., 301 W. Ave 26, Los Angeles 31, Calif.

Oct. 13–16—Federation of Sewage and Industrial Wastes Assns., Municipal Auditorium, Miami, Fla. Details from W. H. Wisely, 325 Illinois Bldg., Champaign, Ill.

Oct. 19–23—National Safety Congress and Exposition, Chicago. Details from R. L. Forney, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

Oct. 26–29—American Public Works Assn., New Orleans, La. Details from D. F. Herrick, Exec. Secy., 1313 E. 60th St., Chicago 37, Ill.

Oct. 27–30—National Water Well Assn. at Hotel Benjamin Franklin, Philadelphia, Pa. Details from Robert R. Storm, Exec. Secy., 811 W. Springfield, Champaign, Ill.

Nov. 8–11—National Inst. of Governmental Purchasing at Netherlands Plaza, Cincinnati, Ohio. Details from Albert H. Hall, Exec. Director, 730 Jackson Pl., N.W., Washington 6, D.C.

Nov. 9–13—American Public Health Assn., Hotels Statler and New Yorker, New York, N.Y. Details from R. M. Atwater, Exec. Secy., 1790 Broadway, New York, N.Y.

1954 MEETINGS

May 4–6—American Public Power Assn., in Chicago

May 4–7—American Welding Society, in Buffalo, N.Y.

June 13–18—American Society for Testing Materials, in Chicago

Sept. 13–15—New England Water Works Assn., in Dixville Notch, N.H.

Oct. 11–14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.

Oct. 11–15 (tentative)—American Public Health Assn., in Buffalo

Oct. 17–20—American Society of Civil Engineers, in New York City

Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York.

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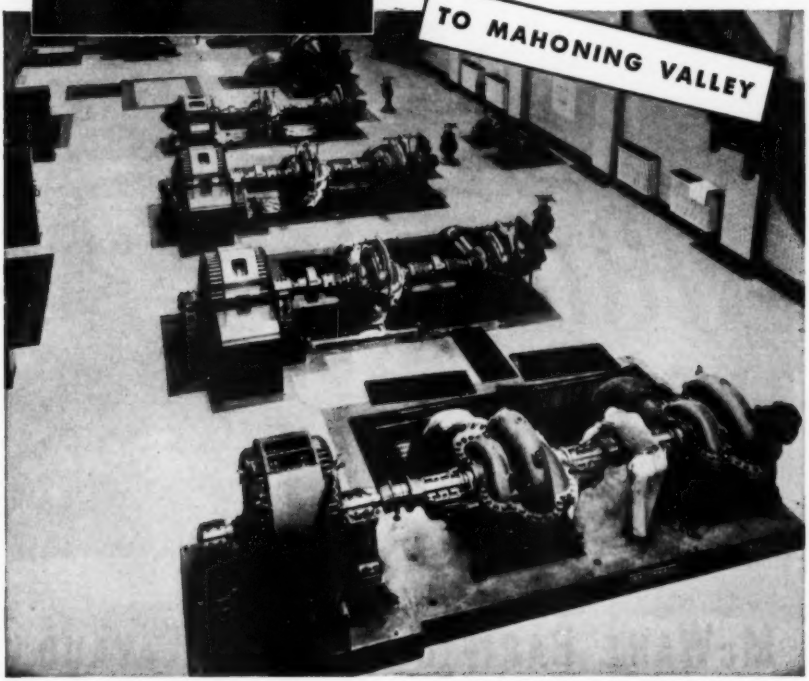

With the addition of a new De Laval 20 mgd centrifugal pump at the Mahoning Valley Sanitary District in Ohio, the station now has a pumping capacity of 60 mgd plus stand-by. This pumping capacity provides for the future program requirements of the water treatment plant.

Vitally important is the fact that the additional facilities were installed without major building alterations or interruptions of service.

The story of De Laval Centrifugal Pumps is one of nation-wide significance, for De Laval units have been serving the districts, large cities and small towns of America for more than half a century. Efficient De Laval Centrifugal Pumps for water works service are available in capacities from 100 thousand gallons per day to more than 100 million gallons per day.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY

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EXPANSION
CONTRACTION
SETTLEMENT
WITH

McWANE-PACIFIC SUPER DELAVAUD
MECHANICAL JOINT CAST IRON PIPE

Practical water or gas distribution men well know that pipe line settlement, expansion and contraction from season to season sometimes cause joint leaks in bell-and-spigot pipe lines.

This kind of trouble may be prevented in future pipe line construction by the use of McWane-Pacific Boltite mechanical joint cast iron pipe. Boltite mechanical joints stay flexible; permit settlement, expansion or contraction without leakage. The special bolts, glands, and sealed-in rubber compound gasket last as long as the pipe.

For details, wire or write McWANE CAST IRON PIPE COMPANY, Birmingham, Alabama, or PACIFIC STATES CAST IRON PIPE COMPANY, Provo, Utah. (Sales offices in principal cities.)

McWANE PACIFIC PIPE *Lasts for Centuries*

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are scientifically designed Measuring Instruments, which have successfully served the Water Works Field since 1885.

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Sounds impossible, doesn't it . . . improving the cast iron pressure pipe that has served so many communities so long and so faithfully?

But the fact remains: today's modernized cast iron pipe is better than ever . . . stronger, tougher, more uniform in quality . . . even more economical and efficient than the cast iron pressure pipe that serves . . . and has served . . . for centuries.

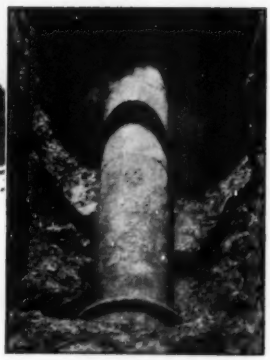
And that is exactly what today's *modernized* cast iron pipe offers the waterworks industry. Cast centrifugally for greater strength and toughness. And, where needed and specified, cement-lined centrifugally for sustained carrying capacity and freedom from tuberculation.

If you want the most efficient and economical pipe ever made for water distribution, your new mains will be laid with *modernized* cast iron pipe with either bell-and-spigot or mechanical joints. Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.

CAST IRON

The Q-Check stenciled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

Modernized **cast iron**



This cast iron water main, uncovered for inspection, is in good condition after 100 years of service in Alexandria, Va.—one of more than 45 cities with century-old water or gas mains in service.

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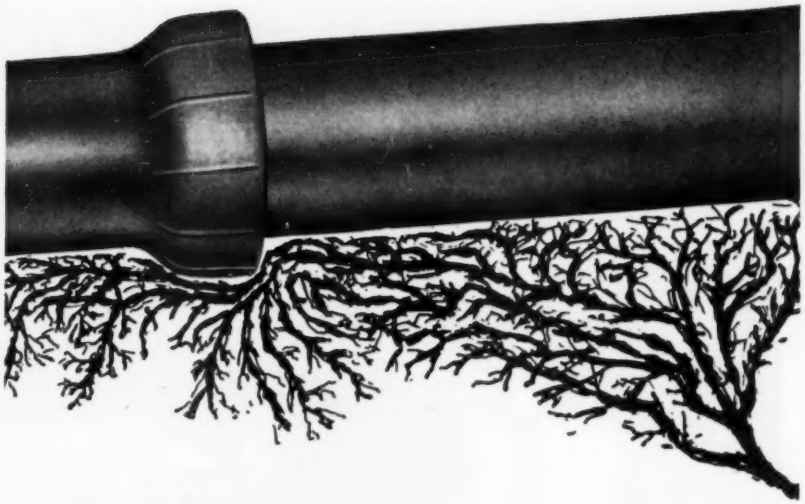

JC-60 SEWER JOINTS
. . . actually turn roots away

An ordinary root may exert pressure as high as 50 psi at the tip. Thus, it is easy to understand why roots are a common cause of sewer line destruction . . . and why foresighted engineers specify ATLAS JC-60®, the synthetic plastic base, *root resistant* jointing compound.

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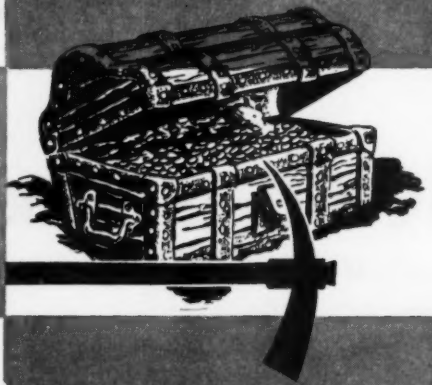
that is...
if they're WELSBACH-*Kitson*



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Not pirate gold or pieces of eight... but that "buried treasure" is the *extra* quality built right into Welsbach-*Kitson* corporation and curb stops. The quality and dependability of Welsbach-*Kitson* products means that you'll have fewer replacement problems... and no costly excavating. They're built to give lasting service and satisfaction. When you install Welsbach-*Kitson* products underground, you'll find that they are really "buried treasure"—but the kind of "buried treasure" you won't want to—or have to—dig up!

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insist on WELSBACH-*Kitson!*

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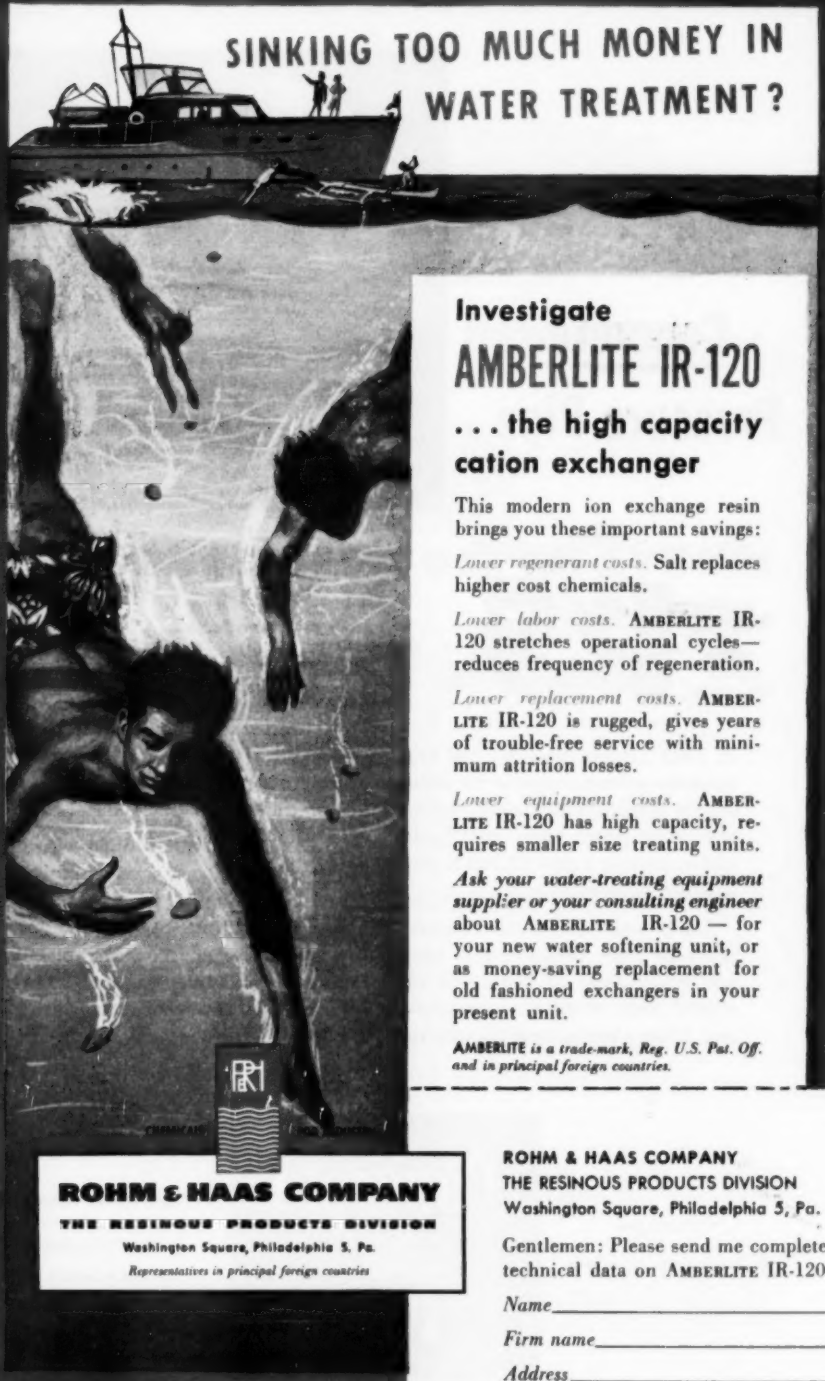

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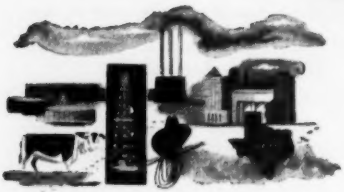
Dallas Prefers Concrete Pressure Pipe



In 1915 Dallas installed the first concrete pressure pipe in its water supply system. Since 1945 several additional miles have been built, and at present a new 23,300 ft. line is under construction.

Dallas engineers prefer concrete pressure pipe because it is easy and economical to install—it requires little or no maintenance—and it has a permanent high carrying capacity. Another important reason for its selection is that water pumped through concrete pressure pipe stays clean—thereby minimizing any odor, taste, and color difficulties.

Like Dallas, many other cities, large and small, are specifying concrete pressure pipe for their water systems. If your city is planning additional water lines, or replacements for old lines, be sure to investigate the advantages of concrete pressure pipe.

Water for Generations to come

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
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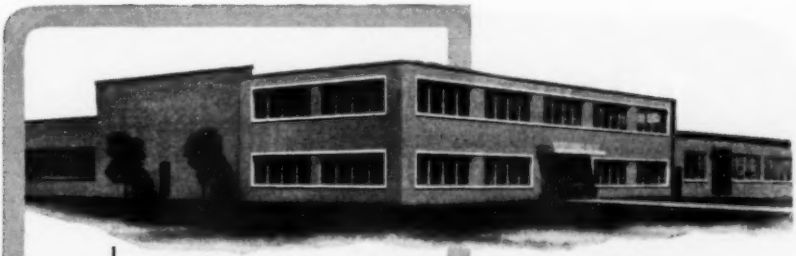

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WALKER PROCESS means leadership

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Armco Welded Steel Pipe comes in lengths up to 50 feet. This means that you could install a mile of this pipe with only 106 joints. And because of these long lengths you have fewer pipe sections to haul and handle, which also helps to cut down installation costs.

Armco Pipe offers you a wide range of diameters (6 to 36 inches) and wall thicknesses (9/64- to 1/2-inch) to simplify size selection.

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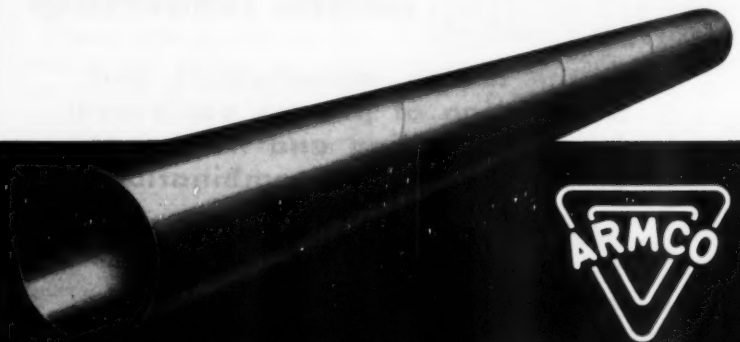
Armco Welded Steel Water Pipe is ideal for supply lines, force mains or water works piping. Write for details. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2483 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.



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Meets A.W.W.A. Steel Water Pipe Specifications

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The Mueller "B" Drilling, Tapping and Inserting Machine will drill, tap and insert or remove corporation stops ½" through 1". It will also insert or remove pipe plugs up through 2½". This work can be done under pressures ranging up to 400 p.s.i.

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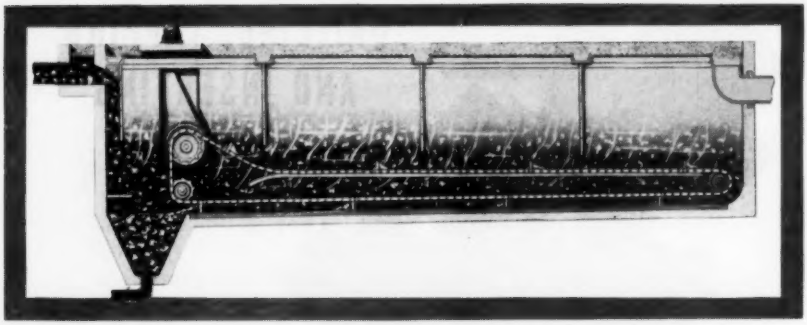

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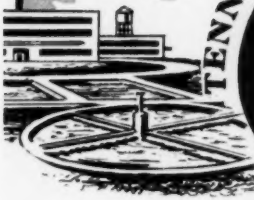

ferri-floc TC TENNESSEE CORPORATION FERRIC SULPHATE

SULPHUR-DIOXIDE HIGHEST QUALITY SO_2

SULPHUR-DIOXIDE

SULPHUR-DIOXIDE is effectively used for dechlorination in water treatment and to remove objectionable odors remaining after purification.

COPPER SULPHATE TC

COPPER SULPHATE

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Because BADGER METER engineers refuse to "rest on their laurels," they continue to maintain the world's highest standards of water meter performance. This new Badger Dovetail Thrust Roller Insert is typical of the constructive research and precision achievements in progress continually at BADGER.

What does this Badger Dovetail Thrust Roller Insert accomplish? It saves important time and replacement costs... because, with this removable plate set into the chamber wall, the thrust roller (in the disc) rolls against the *insert* only... thus preventing wear directly in the chamber thrust roller *slot* (which would damage the chamber itself). If wear occurs on the *insert*, that is no problem, because it can be replaced easily, at a small fraction of the cost and time required to replace an entire new chamber.

In addition, advanced Badger engineering of this unique insert assures you of accurate metering through unimpaired freedom of disc movement, because:

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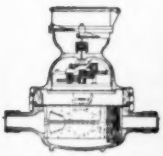
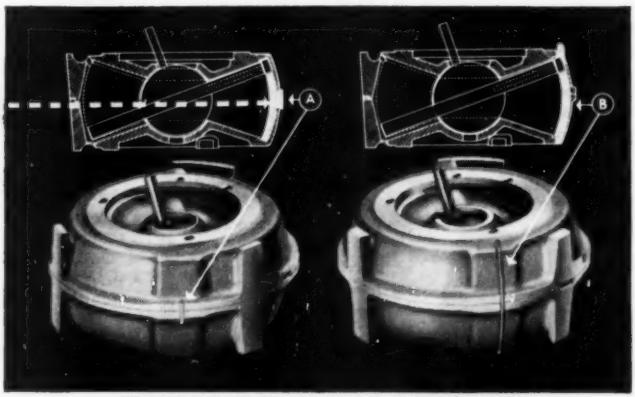
Only in BADGER METERS will you find this advanced type of engineering and precision production which has convinced waterworks men in over 5000 communities that "BADGERS are the best buy in meters."





A New style: 77% shorter slot . . . adds strength to chamber-halves; prevents distortion.

B Old style: This full length slot weakened the chamber-halves . . . made them subject to distortion.

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- Famous "See-Thru" molded plastic measuring chamber suitable for feeding most treating chemicals.
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Cal Says:

"WATER is VALUABLE

in our great Southwest . . .

and we have learned not to waste it. We are always on the lookout for leaks.

"That's why the STUFFING BOX in a CALMET Water Meter caught my eye. This device prevents the leakage of water into the register compartment of a meter.

"Another thing about this STUFFING BOX in a CALMET . . . it contains twice as much packing as is used in other meters, and still doesn't create any undue friction. The packing is treated to minimize friction.

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Why is Demineralization being selected instead of Evaporators?

When should we use three or four-bed rather than two-bed Demineralizers? Mixed Bed?

Should we include a Decarbonator?

How do you figure Demineralizer operating costs?

Which Ion Exchange material should we specify?

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This new Cochrane Handbook answers these and many similar questions and contains flow diagrams and other illustrations giving you the benefit of Cochrane pioneering in this rapidly growing field. Request a copy on your letterhead.

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 45 • OCTOBER 1953 • NO. 10

Promoting Better Public Understanding of What Water Works Service Is Worth

Panel Discussion

A panel discussion presented on May 12, 1953, at the Annual Conference, Grand Rapids, Mich.

Morrison B. Cunningham

Supt. and Engr., Oklahoma City Water Dept., Oklahoma City, Okla.

THERE have been phenomenal increases in the per capita use of water throughout the country. As the population grows, more industries and customers must be served, and long-range planning becomes increasingly important. Water utilities must have adequate income to operate and maintain existing facilities, to plan and construct additions and improvements, and to continue needed research. In order to obtain sufficient revenues, management must promote better public understanding of the value of water works service.

Courteous, dependable service is necessary for good customer relations. It is not what is said, but what is done, that counts. Water works officials must take the customers, as well as utility employees, into their confidence by constantly keeping them well informed. Utility personnel should play an active part in community life. Public appreciation of water service is invariably distinguished by the competent, personal touch of good management.

W. Victor Weir

Pres., St. Louis County Water Co., St. Louis, Mo.

This discussion may well be devoted to stating and answering a number of pertinent questions regarding the financial dilemma facing many water works today.

Why is the water works industry concerned with promoting better understanding of the value of water service?

This concern stems from the fact that water utilities, both municipally and privately owned, generally are

suffering from inadequate income. The result is sometimes poor service. The unprecedented housing boom has, in some places, eliminated the excess capacity, the factor of safety, desirable in plants and distribution systems. New facilities, reinforcing mains, and service mains must be installed at unprecedented unit costs. More income must be forthcoming to finance these facilities.

In some cities, dramatic water shortages have occurred, and bonds have been voted without much difficulty when citizens realized that public health and safety could be furthered for a few cents per person per month. Water works managements do not want such system breakdowns; they want to keep as far ahead of disaster as possible.

Another equally serious but not so obvious situation exists. Inadequate income necessarily causes inadequate salaries and wages. Some utilities are not maintaining the personnel necessary to keep water works service at a top-level standard.

The answer to the problem of adequate financial support seems to be the development by all concerned of a realistic appraisal of the worth or value of water service.

Why is this a current problem rather than one 10 or 15 years old?

The answer is that inflation has only recently caught up with the water works industry. It is a serious problem because water works income has not kept pace with outgo, particularly since the end of World War II.

Material and equipment prices, as well as wages, have risen 50–150 per cent. Water rates have been increased only a fraction of this amount. The addition of new customers has had an embarrassing effect instead of being a healthy growth. New customers now require twice or three times the unit investment in water works facilities needed before Pearl Harbor. Yet many utilities are expected to operate, and to extend facilities, with income from rates based upon prewar costs per customer.

Why is this primarily a utility problem?

Other, nonutility, industries have raised their charges as their costs increased. If a producer's prices were not out of line competitively, and if the value of the product to the customer was still above its cost, that producer had a prosperous business. Nonutility industries base their charges largely on what the product is worth to the purchaser, not on the cost to produce it. If the price gets too far above production cost, however, new competition will develop. Thus, there is an automatic and realistic control of prices.

Utilities, particularly the water works industry, are not blessed with a competitive atmosphere. Water facilities are so costly that no community can afford the luxury of dual systems necessary to allow free competition to establish proper prices. Water works are therefore required to function as monopolies. As the customers cannot leave one utility to go to another that might offer better service or lower prices, controls are placed on most utility activities. Instead of making charges a little lower than the *value* of the service, utilities are allowed to charge only a little more than the *cost* of the service.

The utility problem is acute today because, in controlling rates and income, too much attention is paid to historical costs and too little to today's and tomorrow's costs. There is insuf-

ficient realization that establishing present rates upon prewar plant costs will result in inadequate income and inferior service.

What happens when proper income is not received?

First, the utility is affected. High personnel standards cannot be maintained as the employees leave for better paid jobs. Replacements must necessarily be substandard if wages are substandard. Maintenance suffers. It may become impossible to raise money for plant extensions from bond purchasers. Even if bonds can be sold, the interest rates may be excessive because of the financial insecurity of the utility. There are plenty of examples of "Cinderella" water systems that receive too little of the community's income.

Second, the customer suffers. Service becomes poor and is intermittent in hot weather. Fire protection may become substandard and cause insurance premiums to be increased by an amount greater than that of the water bill of the premises served. Community growth will be stifled because new homes cannot get water service.

Who is responsible for taking measures to put utilities on a firm financial basis?

The answer is plain: the responsibilities lie with the management of each utility. The problem, while general, is actually a myriad of local problems. Each must be solved at home so long as regulation is at the local level, as it is for most municipally and a few privately owned utilities, and at the state and local level for the rest.

But this is no blanket responsibility covering all of the management group of a utility. It is a specific and personal responsibility that must be carried by the general manager, the person actually in charge. Occasionally part of this responsibility may be delegated, but the manager is still ultimately accountable.

What groups have to be "educated" in promoting understanding of water utility problems?

The first group consists of those persons, usually local or state government officials, who have the power to control utility rates. The second group is the general public. John C. Doerfer, ex-chairman of the Wisconsin Public Service Commission, has said (*1*): "The successful management of a utility is more of an art of getting along with people in and out of government than it is the cold, impersonal act of directing the operations of a utility."

In Wisconsin and a few other states, both privately and municipally owned utilities have to convince the regulatory commission and its staff of the need for rates more nearly commensurate with the value of water service. Not only the commissions but also city councils, boards of aldermen, and water boards must be convinced that water utilities need better treatment. These state and local officials have the final say—unless the courts are required to intervene in a situation—and the art of getting along with them must be cultivated.

The public must also be given the water works story. If there is an antagonistic public, it will be difficult to get reasonable treatment from the officials who are regulating rates. The public's attitude should not be unfavorable, and it will not be if the water utility's arguments are reasonable and well circulated. It is not the duty of the citizens to dig out the water utility story; it is management's duty to take it to them.

What water works facts must be better understood?

The principal fact is that good water service costs very little more than poor service. Although the cost of producing good service today and tomorrow may be considerably higher than it was 10 or more years ago, because inflation has obviously caught up with the industry, the costs to the customer are still only a fraction of the value of the service.

The cost of poor service can generally be measured by water rates that were equitable in the prewar period, if they continue to be applied today. The cost of good service will be approximately 25–50 per cent more, unless the utility has experienced a sizable expansion in the last 6–7 years. In some localities, where much postwar construction has taken place, rates must be at least doubled.

Even then, and this is the second fact, the customers and the officials should be shown that water rates are still low when compared with the value of the service. The real value of good water service is many times its price even when based wholly upon present costs of facilities, supplies, wages, and taxes. The author is acquainted with no utility that charges $3.00–$5.00 per 1,000 gal, yet there are thousands of homeowners who pay that much for poor water service. That is the price paid by persons who are beyond the reach of water utility mains and have water hauled by tank truck and dumped into their cisterns, from which they must deliver it to their houses with small electric pumps. The price of $3.00–$5.00 is set by the water haulers, who compete for business. As business is good, the value of the water must be even greater to the purchasers. To them 1,000 gal of potable water is worth more than a case of beer—quite contrary to the attitude of many customers who think the price of 1,000 gal of water should be about the price of a single bottle of beer.

Another fact that has to be sold is that today's high prices are here to stay. They are inflated, but not in the sense that equal deflation will follow. There is no place for wishful thinking that water utilities are in a temporarily critical phase which will be ended by deflation. No historical pattern indicates that deflation, when and if it occurs, will have more than a minor effect.

These economic facts of life are being recognized by the courts in several states, where regulatory commissions have been told that net historical cost to the first person putting facilities into public service is not the only measure of value for rate-making purposes (*2*).

How should the water works picture be presented?

The answer to this question varies with each utility. There are, however, some common factors. The water utility manager must take positive action to get information to the officials and the public, either by doing it himself or by delegating a portion of the work to some competent person or agency. He should recognize this as a part, an important part, of his job. He should work at it continually.

If the manager heads a utility in a growing city of 50,000 population or larger, he will probably not have time himself, nor will he have anyone in his organization, to do a competent job of handling all the work involved. He should do the same for public relations as he does for engineering—hire or retain a specialist. If it is impossible to retain an outside consultant, a person with public relations ability should be put on the payroll as an assistant

in some capacity. The money will be well spent. His services will make for better relations with the public and better service to the public.

The manager should insure that the public connects him or his staff, by name, with water works activities. He himself is ultimately responsible, however, and he should be out in front accepting that responsibility. The water utility business is not an impersonal, institutional affair. It is conducted by able, competent people. Their names, and certainly the manager's, should not be hidden but should be known to the public. This condition will automatically be brought about if the manager and his staff follow proper methods of presenting the water works picture.

It is not necessary to describe here the avenues of communication of the utility with government officials and the public. The methods and media to be used have been well covered in AWWA publications and should already be filed in the office of every utility.

Reference

1. Doerfer, J. C. Management of Municipal Water Utilities. *Jour. AWWA*, **45**:357 (Apr. 1953).
2. *Chesapeake & Potomac Telephone Co.* v. *Public Service Commission* (Md Ct App 1952) 97 PUR NS 50, 93 A2d 249; *New England Telephone & Telegraph Co.* v. *Public Utilities Commission* (Me Sup Jud Ct 1953) 98 PUR NS 326, 94 A2d 801; *Illinois Bell Telephone Co.* v. *Commerce Commission* (Ill Sup Ct 1953) 98 PUR NS 379, 111 NE2d 329.

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Water utilities no longer have to sell water service to communities. Practically every house where water service is available now takes it. This has been a gradual development over the decades. A study of the statistics of a large group of cities showed that, for the average water works, which in the Midwest was built in the period from 1870 to 1890, it took 20 years before the ratio of population to consumers was as low as 8:1. This study also disclosed that in cities (varying in population from 45,000 to 155,000) where a public supply had been available for an average of more than 40 years, there was an average of one water service for each 6.3 persons. At present in practically all cities, other than those with a large proportion of apartment buildings, the ratio of population to consumers is 4:1 or smaller.

Essential Facts

The problem now, therefore, is not one of selling water service but of acquainting the users with the relevant facts. Among those facts, of which the ordinary water consumer has little appreciation, are:

1. All water service is cheap. More than 50 per cent of all the water consumers in the United States are paying less than 1.5 cents per capita per day for water service. They are paying, on the average, one-third to one-fifth as much for water as for electricity and less than half as much as for telephone service. Water for industrial uses is ordinarily sold at 2–4 cents per ton.

2. The difference in cost between mediocre and excellent water service rarely exceeds a fraction of a cent per capita per day. As the total cost of water service averages only approximately 1.5 cents per capita per day, an increase of but 0.5 cents per capita per day for the residential users would add one-third to the domestic revenue.

3. For the municipally owned plants (approximately 80 per cent of the total), the customers and the stock-

holders are the same people. Their increased water rates simply enable their water works to give them better service. Under public utility commission control of private utilities, the facts are the same, although less obvious.

3. The consumers should be advised that the expenditure of approximately $150,000 for new water facilities is required for each 1,000 people added. This is five times what it cost 40–50 years ago. The need for financing new construction at the higher cost level is necessarily reflected in the increased cost of all water sold.

4. The cost of water is now comparatively the lowest ever experienced. Fifty or a hundred years ago a laborer worked more than a week to earn enough to pay his annual water bill. In 1953 it takes him only about a day.

Public Contacts

It is believed that personal contact of water works management with the responsible city officials and the leaders of service organizations is usually the most effective means of promoting better understanding between the utility and the community it serves. What is generally referred to as "public relations" is, in fact, a composite of human or personal relations.

An illustration is provided by the experience in a Midwest city served by a private water company which found it necessary to apply to the public utility commission for a rate increase. Before doing so, the management made contact with the city officials and laid before them the facts regarding increased operating costs and the effect of decreasing net revenue upon the ability to provide the quality of service to which the community was accustomed.

The water in that community was always of satisfactory bacteriological quality, but it varied in hardness from 85 to 770 ppm during the year. The city officials stated that, if they paid higher rates, they would like to have the hardness reduced. It was explained to them that an overall rate increase of approximately 35 per cent would be required to continue the existing quality of service and that, for an additional 25 per cent increase, the hardness could be reduced so as to maintain it uniformly at 85 ppm. For the average residential user, the added cost of the reduction in hardness would be approximately 1 cent per day.

The local luncheon clubs became interested and seventeen such organizations petitioned the city officials to approve the larger increase and get softened water. The city joined the company as a coapplicant to the public utility commission for a change in rates which would yield the revenue necessary to provide for both the increased operating costs and the softening.

It was agreed that the new rates would not go into effect until the softening facilities were ready to operate. They have now been in operation for more than 2 years. Both the public and the company are well satisfied. This result was accomplished without lengthy and costly hearings, customer relations were not disturbed, and the public's appreciation of the company's service is now at its highest level.

Not all efforts to acquaint the public with the water utility's problems are so successful, but long experience in rate regulatory commission matters leads to the conclusion that such attempts are almost invariably worth while and that, when the customers are fully acquainted with the revenue requirements for good service, they are willing to pay its cost. Sometimes the politicians thwart the consumers' views in

that regard, but, if the civic leaders are familiar with the water management's problems, there is, at least, a smoother path toward a better understanding of what water works service is worth.

John H. Murdoch Jr.

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Short-term results in public acceptance of the need for increased water revenues can usually be obtained by comparatively simple procedures. Worth-while long-term results require a change in the mental attitude of water works officials and a slow, laborious educational campaign. Water customers are generally fair minded and can be counted upon to do the equitable and just thing once they have been given an honest, thorough presentation of facts needed to form a well-grounded judgment. A showing of increased costs of operation over the years, as compared with increases in revenues, has often proved sufficient to lead to public acceptance of a need for a rate increase. Actual decreases in the dollar amount of net operating income are far from exceptional in growing communities, and the public at once understands that such trends mean disaster if allowed to continue. In other instances, it can be demonstrated, by comparison of figures for significant periods, that, although the dollar amounts of net operating revenues are increasing, the percentage of operating revenues used up in operating expense—the operating ratio is also —increasing, while the plant investment and the investment per added customer are snowballing. Again the public will understand and accept rate increases.

Too few water works officials and too few of their customers realize the true cost of water service. No matter what the sources of funds—taxes, municipal bonds, front-foot assessments, real estate developments, corporate bonds, common stocks, or contributions—the property paid for by those funds is devoted to an essential public service, even if the bonds have been redeemed and the contributors are dead and buried. Studies should be made to learn just what physical property is now in service—not the dollar value but the actual land, buildings, machinery, pipe, tanks, and equipment. If dollar equivalents must also be mentioned, the public should be told what the inventoried property would cost in today's shrunken dollars.

Service extensions are a constant headache. The public should be given the facts about the cost of a mile of main in typical years and in 1953. The historical cost of the distribution system per mile of main should be compared with the cost per mile of additions to that system.

These and similar presentations have often proved helpful. They lead to a better public understanding of the worth of water works service, if the public has confidence in the integrity and professional ability of the utility officials. Such confidence must be earned and, once earned, must never be abused.

In the long run, a revolutionary change in the attitude of water works officials is required. Several years ago a study was made of the origins of a number of typical public water supply enterprises. Old newspaper files for the period of development were examined in public libraries. It is of interest to note that an intensive campaign always had to be carried on by a few public-spirited leaders and that public apathy was evident. The lead-

ers stressed the need for public fire service and for street sprinkling to wet down summer dust. The households were then dependent on wells and cisterns for their water, and, at first, little emphasis was placed on the advantages of a supply for domestic use. Later, when it became evident that, to be financially successful, the public water supply system needed domestic users, the officials sold their service in competition with the wells and cisterns. They argued convenience, but they stressed low price. As knowledge of the increasing health hazards of private backyard supplies was acquired, the idea of public supplies for domestic use became generally accepted, but the curse of the old emphasis on cheap price remains. Water officials still act as though they were in competition with private supplies on a price basis. They still plead poverty as an excuse for inadequate service, although what the modern community wants is highest quality, adequate quantity, and wide availability.

Water works management should conduct a continuous educational campaign showing how the public water supply system could be improved, instead of merely defending present systems against complaints on the grounds that they cannot afford to render really first-class service. The aim should be to establish a desire for quality service—a desire so strong that the public will gladly pay the cost.

Until water works officials stop thinking and acting like managers of bankrupt bargain basements, interested only in moving the stock at whatever price it will bring, and begin to adopt the attitudes of successful sellers of quality goods, the public will not understand the worth of water works service.

This Association has done much to promote public understanding by pointing the way to better service. Industry leaders and manufacturers have been active in advancing knowledge of the science and art of good service. More will be done in the future. Each water utility has its own peculiar problems, and it is difficult to weigh the relative efficiencies of the various systems. It would be useful to undertake a long-term project to devise a system for the objective grading of physical and economic efficiencies in order to set up ideal standards toward which to work. There should also be a long-range study of the economics of public water supply, one purpose of which would be to determine how the increased cost of improved service could be financed.

Better water service should be the goal. If properly sold, better water service will be properly appreciated by the public.

Samuel B. Morris

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The important public relations subject, "What water works service is worth," should be considered not in its narrow sense, the charge for water or its monetary value, but in its broadest aspect, the need of the community for adequate water of good quality to meet all consumer and fire protection demands. Those who administer water works in semiarid areas have an advantage in the fact that the native population, at least, generally understands that neither vegetation, crops, man, nor cities can exist without water. In the arid Southwest, a person does not have to go far to reach the barren desert wastes where he can learn this truth

for himself. He can easily experience personal anguish and fear of thirst should his car stall on a lonely desert road amid the dry sand and cacti.

Of course, the best public relations is achieved through a job well done, but this in itself is not sufficient. As cities and irrigated areas become more extensive and efficient operations provide continuous, unfailing water supplies, the population gets more and more accustomed to service at the turn of a faucet. With the rapid infiltration of settlers from the humid climates of the East, it becomes increasingly necessary to furnish educational material to these new citizens, as well as to the "old timers" who may have forgotten the "shotgun arguments" over water rights, a tradition among the pioneers of the Southwest.

Los Angeles Situation

Southern California has less than 2 per cent of the natural stream flow of the state and more than 50 per cent of the state's population. The Los Angeles Dept. of Water and Power tells this story often and does not let the citizens forget that it was the foresight, determination, courage, and sacrifice of the pioneers which brought water from the Sierra Nevada, 338 miles to the north, and from the Colorado River, 340 miles to the east. This importation of water over great distances now enables more than 2,000,000 people to live in the 453 sq miles of Los Angeles; more than 4,000,000 people, in the Metropolitan Water Dist. of Southern California; and more than 5,000,000, in the 2,500 sq miles of gently sloping valley and rolling hills facing the Pacific in the southern part of the state. A recent news release indicates that the center of population in California is within the city limits of Los Angeles, 220 miles south of the geographic center of the state.

In earlier years it was necessary to go before the people from time to time to secure their 2:1 favorable vote for bonds required to finance the continued expansion of water and power facilities to meet the growing needs of the city. These intensive bond campaigns provided the necessity and opportunity for highly organized employee and citizen activity, with many talks to civic, service, fraternal, school, and other organizations, and with consequent large newspaper coverage. House-to-house campaigns were required. The cost of printing and advertising was met by voluntary contributions from the employees. Sometimes, particularly for proposed power bond issues, the necessary 2:1 vote was not secured. This failure was largely due to strongly organized and financed opposition by privately owned electric utilities, which were then still in competition with the municipality in distribution to some areas of the city.

In 1947 a large majority vote approved a charter amendment authorizing the Los Angeles Board of Water and Power Commissioners to issue revenue bonds. This action has made it possible for the department to plan and finance its rapid expansion in a confident and orderly manner. The necessity for this authority can be understood when it is realized that the city's population increased by nearly 500,000 in the last decade, a growth of 31 per cent, while water sales increased 68 and electric sales 118 per cent. To meet this large-scale growth, postwar capital expenditure to June 30, 1952, has been $73,000,000 for water and $186,000,000 for power, a total of $259,000,000.

LOS ANGELES CITY-OWNED DEPARTMENT
WATER AND POWER
In 1869—Water for Los Angeles' first iron horse
The "Sun Gabriel" was the first locomotive on the Los Angeles and San Pedro, only railroad in Los Angeles in 1869, when the city had only 5500 residents and needed little water. Six years later the first transcontinental railroad reached Los Angeles, starting the phenomenal growth that was to make this the nation's fourth largest city. Water for the incoming thousands became the city's most pressing problem. In overcoming this obstacle, the people of Los Angeles made possible the modern metropolis.
TODAY IN LOS ANGELES
A growing water system is building a greater city
To augment local sources of supply, huge aqueducts have been built to bring water here from the High Sierras and from the Colorado River. Now the widespread system of water storage and distribution inside the city limits constantly is being enlarged and extended to deliver the water to new homes, business, and industry in Los Angeles' 453 square mile area.
Construction work goes on unceasingly to meet ever increasing demands for more water. New installations are being paid for partly out of present earnings and partly out of funds raised through revenue bond issues, with those bonds to be paid off out of future earnings. And though costs of building and operating the Water System continue to rise along with the cost of living, your Department has held the line against water rate increases. Water in Los Angeles costs no more today than ten years ago. *You can still buy all the water you need for less than 5 cents a ton.*
50 Years of Service • 1902-1952
LOS ANGELES CITY-OWNED DEPARTMENT
WATER AND POWER

Fig. 1. "A Growing Water System Is Building a Greater City"

Los Angeles has an annual public relations budget of $489,000, of which $249,000 is for advertising. Of these totals, the water expenditures planned for 1953–54 are, respectively, $176,000 and $60,000.

In 1947 the department gave up the old-style statistical annual report in favor of a modern brochure with attractive color and format (*1*). Movies are provided for schools and service clubs. The department speakers' bu-

reau grasps every opportunity to tell the story of water and power. Timely pamphlets are issued, with such titles as "Fifty Years of Service to Los Angeles, Your City-owned Department of Water and Power" and "Water and Power—Community Builders." The department participates in home shows, sportsmen's shows, and other exhibits with appropriate pamphlet handouts.

The metropolitan press and community newspapers carry the department's advertisements, which are of the institutional type and, especially in power, are aimed at favorable promotion and load building. A few of these advertisements will be described to illustrate how the department tries to give the citizens a better understanding of what water works service is worth.

Historical Series

In celebration of the fiftieth anniversary of the department, it ran a series of historical ads. The first ad in the series depicted a senorita, symbolic of Los Angeles' Spanish origin, pouring a drink of water from an "olla" (water jar) for a Yankee newcomer. The text gave the historical background and contrasted it with the present:

In 1850 the first U.S. Census counted 1,610 persons in Los Angeles. The dusty little pueblo of Los Angeles, founded in 1781, was incorporated as an American city in 1850. The first U.S. Census that year listed 1,610 people living in the city's 28 sq miles. Water jugs had to be filled from crude "zanjas" or ditches, the city's only water system.

Today in Los Angeles water has created a green garden for 2,000,000 people. Ample water supply and distribution have made possible a 453-sq mile city of lawns, parks, gardens—a city more than a thousand times as big in population as the pueblo of 1850. As water flows, Los Angeles grows. Today the built-in water works capacity of Los Angeles is farther ahead of immediate needs than in any other city. New facilities as they are constructed are being paid for out of current and future earnings. Your Department of Water and Power supports itself and builds for tomorrow. Yet it brings you life-giving water for less than 5 cents a ton. Almost everything else you buy costs more, but water rates have remained constant in Los Angeles since 1941.

The second ad in the series pictured the city's first reservoir, a brick structure located in the plaza, which was the center of the city's business and social life in the early period. Historical background was provided in these words:

In 1860 the city's first reservoir held a day's water supply for 500. A simple tank of hewn planks held together by bolts and tie rods and perched atop a brick foundation was the first reservoir in Los Angeles. Built in the Plaza in 1860, the tank was only 20 by 30 ft in size, held about 80,000 gal, and at today's rate of use could supply water for about 500 persons for one day.

The main body of the ad, presenting the present-day story of water service to Los Angeles, was introduced by this headline: "Today in Los Angeles water is stored a year ahead for 2,000,000."

In the next ad (Fig. 1) the point of interest was an early railroad station, which was pictured together with Los Angeles' first railroad locomotive. The Los Angeles city seal and standard signature of the Dept. of Water and Power, shown at top and bottom, appear on all department ads.

The theme of the fourth ad in the series was the installation of Los An-

LOS ANGELES CITY-OWNED DEPARTMENT
WATER AND POWER
In 1904-
Los Angeles faced a water shortage
A series of unusually dry years and a steadily increasing population had created a shortage in the local water supply. The "Zanja" system of ditches, which had served the city for more than 100 years, had to be abandoned in 1904 to conserve water for domestic use. This curtailed water for fields and orchards within the city limits. Aroused to the need of importing additional water, Los Angeles citizens in 1905 overwhelmingly approved the city's first official steps to bring water here by an aqueduct from the High Sierras.
TODAY IN FAST-GROWING LOS ANGELES
Building water works is an unending job
The Los Angeles, Owens, and Colorado Rivers now provide Los Angeles with ample sources of water supply. Two huge aqueducts have been built to transport water here, one from the Owens River in the distant High Sierras, and another built by the Metropolitan Water District from the Colorado River. But extending the water distribution system to serve the increasing number of people who live and work in the 453 square miles of fast-growing Los Angeles is a never-ending job.
As the city grows, the Water System must build more and more distribution pipelines, reservoirs, pumping plants and other water works to meet the people's expanding needs. This large-scale construction program, expected to total $83,000,000 over the next five years, is being financed partly out of current earnings and partly by borrowing funds through revenue bonds, which must be paid out of future earnings. Yet in spite of these huge investments in construction, and the rising costs of materials and services, your Department of Water and Power has kept rates low . . . so low that you may use all the water you need in Los Angeles for less than 5¢ a ton.
50 Years of Service • 1902-1952
LOS ANGELES CITY-OWNED DEPARTMENT
WATER AND POWER

Fig. 2. "Building Water Works Is an Unending Job"

geles' first water meter, which was shown in a drawing carrying this legend:

In 1889 first water meter installed in Los Angeles. The first water meter in Los Angeles was placed at Macy Street and Mission Road in 1889. The use of meters increased slowly. As late as 1902, when the city bought and took over the operation of the water system, there were only 319 meters in use. Under municipal ownership, however, meters were installed rapidly, resulting in water con-

servation and more effective use of the city's water supply.

Today in Los Angeles 446,000 meters are operating in a vast water distribution system.

The next ad emphasized the fact that the water system of Los Angeles has developed as a result of solid citizen support. The drawing showed a newsboy selling papers with the headline: "Water bonds carry." The text of the ad explained:

In 1901 $2,000,000 bond issue passed to purchase local domestic water system. Los Angeles citizens of 1901 recognized the need for better water service if their city was to prosper. They approved a $2,000,000 bond issue by a 5 to 1 majority, to buy the local domestic water system and place it under municipal operation. The purchase, completed in 1902, was the largest single investment the city of 100,000 people had ever made, acknowledging the top importance of water in Los Angeles' future.

Today in Los Angeles a modern water system serves a city of 2,000,000.

The sixth ad (Fig. 2) called attention to the fact that planning and expansion of the municipal water system were necessary to overcome an early-day critical shortage of supply. The next ad took its theme from the beginning of construction of the Los Angeles Owens River Aqueduct. The scene shown involved the construction of the Elizabeth Lake Tunnel section of the aqueduct, where the first caterpillar tractor ever built was used. The text stated:

1907—building Elizabeth Lake Tunnel to bring water to Los Angeles. The 5½-mile Elizabeth Lake Tunnel section of the Owens River Aqueduct was the key which unlocked the water storehouse of the High Sierras for Los Angeles. Started Sept. 20, 1907, the tunnel pierced the ramparts of the Coast Range and made possible the daily delivery of 284 mil gal of water to Los Angeles. Skillful planning and engineering by pioneers of the City Water System included the use of the first "caterpillar" type tractor ever built and helped complete the project on Feb. 28, 1911, in two-thirds the estimated time at two-thirds the estimated cost.

The importance of maintaining an ample water supply was then emphasized in the text describing the present-day situation, under the headline: "Today in Los Angeles ample water supply means growth and prosperity."

In the final ad in this historical series to be described, William Mulholland, the first superintendent of the Los Angeles municipal water system, was shown making the first surveys for the Colorado River Aqueduct. The text told the story:

In October 1923 William Mulholland, "father of the Los Angeles municipal water system," began surveys to find a route for a new aqueduct to bring water to Los Angeles from the Colorado River, more than 300 miles away. The pioneer water engineer foresaw that even the mighty Los Angeles Owens River Aqueduct he had completed 10 years earlier would not be enough to take care of Los Angeles' miraculous growth. Based on Mulholland's surveys, the giant Colorado River Aqueduct was built by the Metropolitan Water District, formed by Los Angeles and twelve other cities. The thirteen farsighted communities voted $220,000,000 in bonds to build the new lifeline from the Colorado, which now serves 45 Southern California cities.

Today in Los Angeles Colorado River water enables a city of 2,000,000 population to keep growing. The foresight and planning of pioneer leaders and the support of Los Angeles' citizens have given the city a dependable three-way supply

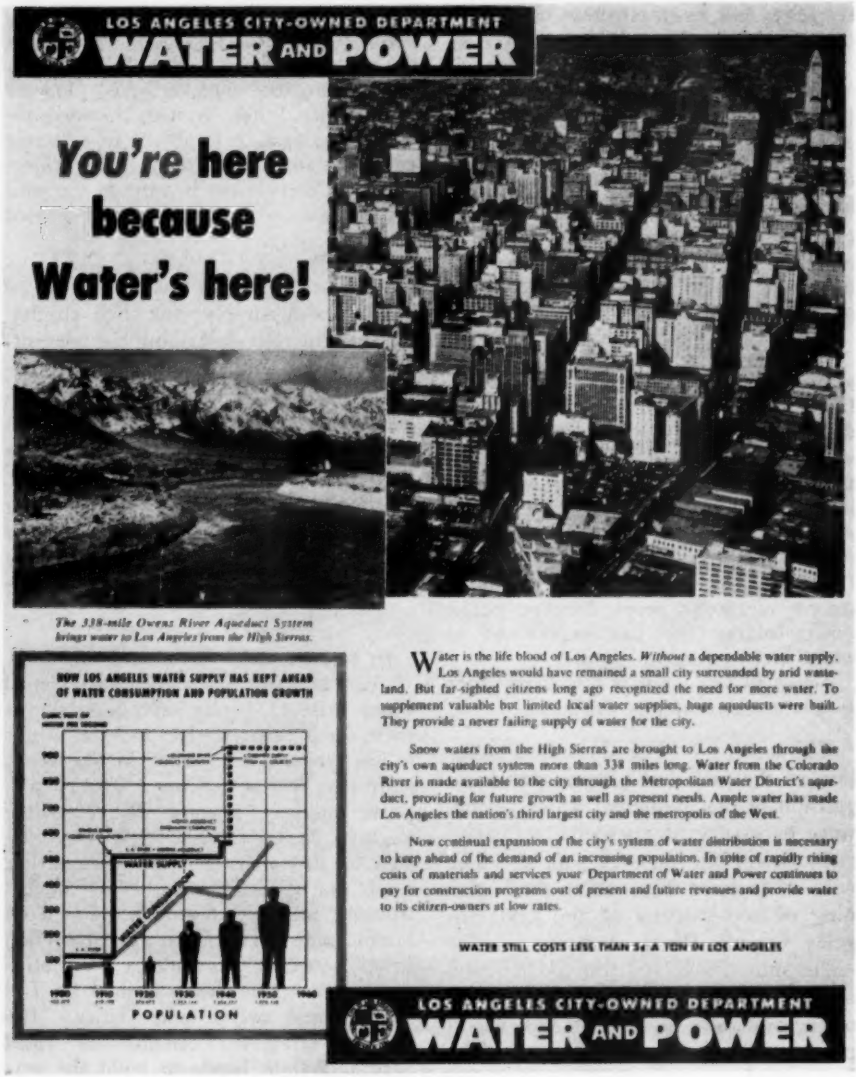

LOS ANGELES CITY-OWNED DEPARTMENT
WATER AND POWER
You're here because Water's here!
The 338-mile Owens River Aqueduct System brings water to Los Angeles from the High Sierras.
HOW LOS ANGELES WATER SUPPLY HAS KEPT AHEAD OF WATER CONSUMPTION AND POPULATION GROWTH
WATER SUPPLY
WATER CONSUMPTION
POPULATION
Water is the life blood of Los Angeles. Without a dependable water supply, Los Angeles would have remained a small city surrounded by arid wasteland. But far-sighted citizens long ago recognized the need for more water. To supplement valuable but limited local water supplies, huge aqueducts were built. They provide a never failing supply of water for the city.
Snow waters from the High Sierras are brought to Los Angeles through the city's own aqueduct system more than 338 miles long. Water from the Colorado River is made available to the city through the Metropolitan Water District's aqueduct, providing for future growth as well as present needs. Ample water has made Los Angeles the nation's third largest city and the metropolis of the West.
Now continual expansion of the city's system of water distribution is necessary to keep ahead of the demand of an increasing population. In spite of rapidly rising costs of materials and services your Department of Water and Power continues to pay for construction programs out of present and future revenues and provide water to its citizen-owners at low rates.
WATER STILL COSTS LESS THAN 3¢ A TON IN LOS ANGELES
LOS ANGELES CITY-OWNED DEPARTMENT
WATER AND POWER

Fig. 3. "*You're* Here Because Water's Here!"

of water—from local sources, from the Owens River Aqueduct, and from the Colorado River Aqueduct. Approximate capacity use of the first two sources has now been reached. So your city-owned Department of Water and Power has under construction a $7,000,000 new trunk line connection to start using increasing amounts of this city's share of Colorado River Aqueduct water. Los Angeles must remain ever alert to protect her rights in this vital source of water.

An estimated $75,000,000 will be spent in the next 5 years to build additional reservoirs, trunk lines, and water distribution facilities to keep water flowing to fast growing Los Angeles. This expenditure will be financed from the earnings of your city-owned system and funds borrowed through revenue bond issues. Yet, despite rising costs of materials and services, municipal water rates in Los Angeles are still at prewar levels. Water still costs less than 5 cents a ton in Los Angeles.

Water and City Growth

In another ad (Fig. 3), the importance of an ample water supply to the growth and development of a large city provided the basic theme. The principal illustration was an air view of the business center of Los Angeles, with a smaller picture showing the 338-mile Owens River Aqueduct system. A diagram illustrated how the Los Angeles water supply is kept ahead of water consumption and population growth.

A recently published advertisement further emphasized the close relationship between water and population growth. One picture showed a crowded downtown street in Los Angeles and another a giant steel siphon through which the water plunges up and down mountainsides on its 338-mile journey to the city. The distances over which water is imported to Los Angeles from the High Sierra and from the Colorado River were stressed in a drawing accompanying the photos. The headline and text read:

Never before water for so many . . . from so far! Never before in the world's history has so large a city been built so far from its major sources of water supply. Four-fifths of the Los Angeles city water supply must be brought here from sources as far away as 338 miles. And yet our municipal water supply system not only provides abundant water for present needs but also has a built-in capacity for future requirements proportionately greater than in any other big city. With adequate sources of water, your municipal water system now is concentrating on expanding the in-town distribution system to meet the city's never-ending growth. Additional closein storage and regulatory reservoirs, major pipelines, pumping plants, mains, and other facilities are being built in a 5-year $85,000,000 expansion program. This large-scale program is being financed partly out of current revenue and partly by issuing revenue bonds to be paid for out of future earnings. In spite of the great distances over which water is "imported," the big investment being made in new facilities, and the rising costs of all materials and services needed by your water system, water rates in Los Angeles are still at the same low preinflation level of 10 years ago. Water still costs less than 5 cents a ton in Los Angeles.

These advertisements illustrate how Los Angeles promotes better understanding of what water works service is worth. This is no one-man job. The department's public relations director, its advertising agency, the Advertising and Public Relations Committee of the Los Angeles Board of Water and Power Commissioners, Chief Engr. of Water Works and Asst. Mgr. Burton S. Grant, and the author, in his capacity of general manager and chief engineer, have all cooperated in this most important phase of the administration of the Los Angeles Dept. of Water and Power.

Reference

1. MAYER, E. B. Making Annual Reports Interesting. *Jour. AWWA*, **42**:9 (Jan. 1950).

Application of Vertical Pumps to Water Works Installations

By Thomas M. Niles

A paper presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich., by Thomas M. Niles, Partner, Greeley & Hansen, Chicago.

ALTHOUGH horizontal double-suction pumping units predominate in water works installations, vertical pumps have a good many advantages. Their application should be more general in the water works field.

This paper deals principally with vertical-shaft, single-stage, end suction, motor-driven, volute pumps, as compared with horizontal double-suction pumps. Other types of vertical pumps are applicable under certain conditions. In low-head, high-capacity, wet-pit installations, for instance, propeller pumps, either axial or mixed flow, may be used. Deep well turbine pumps, designed and developed primarily for use in wells of restricted diameter, have sometimes been used for pumping stations, particularly in wet-pit installations where the discharge head is high. As these pumps have been developed for a special purpose, however, it seems logical that volute centrifugal pumps, of unrestricted diameter, would be preferable. The availability of well type pumps as an item of established production has apparently been an important consideration in their use at pumping stations.

Saving in space and low elevation of the pump with respect to the motor have sometimes been attained by the use of double-suction pumps with the shaft placed vertically. Here again the availability of the double-suction designs has been an important factor.

In a double-suction pump, the suction portion of the casing is intricate and the path of the water is tortuous as it approaches the impeller. In an end suction pump with an overhung impeller, the discharge volute portion of the casing is about the same as for the double-suction pump, but the entrance to the impeller is much simpler and is direct. Not only are the intricacies of the suction portion of the casting eliminated, but the water entering is not obstructed by the shaft.

Zones of Application

To date there have been many more applications of horizontal double-suction pumps than of vertical end suction pumps. This is particularly true for capacities less than 14 mgd at heads greater than 60 ft. Figure 1 is a diagram on which have been plotted a good many actual applications of single-stage, horizontal double-suction pumps of various capacities and various heads. The chart is divided into six zones—three capacity ranges (less than 14 mgd, 14–60 mgd, and more than 60 mgd) at two head ranges (less than

60 ft and 60 ft or more). Of the installations shown, none exceeds 100-mgd capacity, and only approximately 2 per cent exceed 60 mgd. Nearly half of the installations are in the high-head, low-capacity zone, and the applications are well distributed through the low-head, low-capacity and both the low-head and high-head, intermediate-capacity zones.

Figure 2 shows a similar plotting of actual applications of single-stage, vertical end suction pumps. This chart is divided into the same zones as Fig. 1. Included are applications for water works pumping, irrigation, drainage, and condenser circulating uses. No sewage pumps are shown. The total number of vertical applications in Fig. 2 is approximately one-third the total

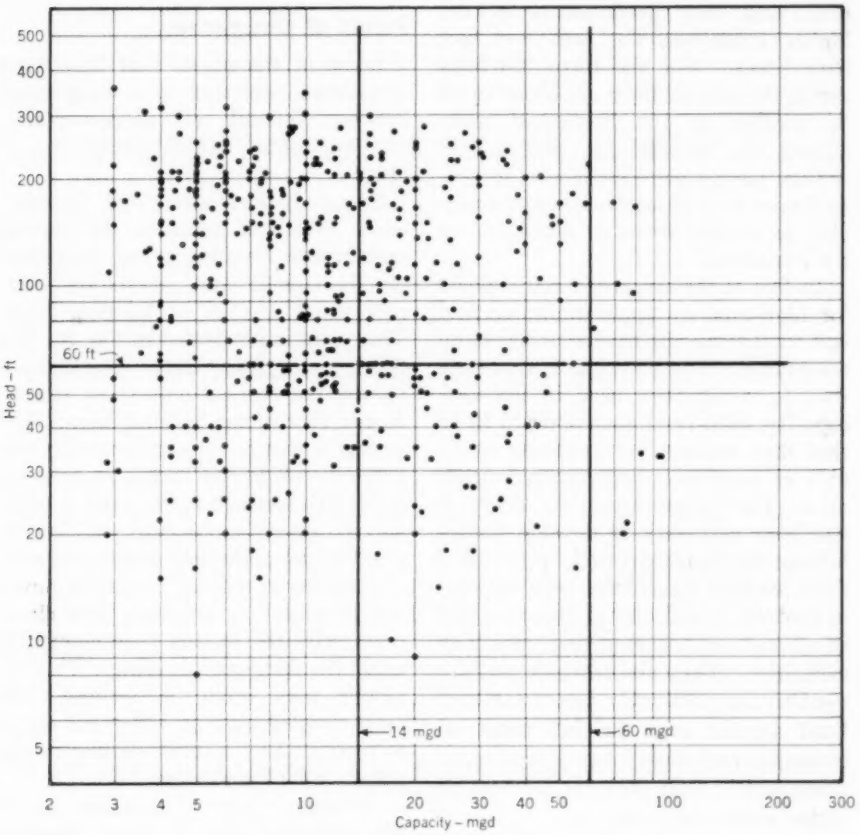


Fig. 1. Horizontal-Pump Applications

The chart shows the distribution, by head-capacity zones, of actual applications of horizontal double-suction pumps.

number of horizontal installations in Fig. 1. The greatest difference is in the high-head, low-capacity zone, where the horizontal units outnumber the vertical approximately 70:1. In other zones, many vertical units appear, and they predominate in the higher capacities, for both low and high heads. For the three low-head zones, the vertical units are about equal in number to the horizontal units among the installations plotted. If sewage pumps were included, the vertical type for low-head use would probably be several times as numerous as the horizontal.

In five of the six zones, particularly for high-capacity applications, vertical end suction pumps have found general acceptance. The principal reason why they have not been used in the low-capacity, high-head zone appears to be that they are not yet generally available as regularly manufactured products. For large capacities, where it has been necessary to develop pumps beyond the range covered by standard lines, vertical types have been selected in probably a majority of instances and in all installations requiring very high capacities. They are available and are used to a considerable extent for low-head service over the full range of capacities and could be employed much more widely than they are for low-lift water works pumping.

One reason vertical pumps are coming into more general use for high-head conditions is that, in recent years, pumps have been developed for higher heads with a single stage. To quote one designer, "Vertical end suction units can be made for high heads per stage and, with proper suction conditions, could be made for 500-ft head in a single stage with good efficiency." Where heads are high enough to require two or more stages, the vertical end suction units do not lend themselves conveniently to series or multistage construction with a single motor.

Points of Comparison

Some of the points that have been considered pertinent to a comparison between vertical end suction pumps and horizontal double-suction pumps are:

Space requirements and building costs. Without question, the vertical units can be installed in less space than the horizontal and, therefore, offer substantial savings in building costs. This point is illustrated in Fig. 3. For the strictly comparable installations shown, the vertical unit saves at least 30 per cent of the building area. The saving in cost is, of course, not directly proportional to the saving in area but is nevertheless substantial, and it probably is always more than sufficient to pay for any additional equipment cost.

Flooding of motors. Vertical pumps can be placed at relatively low elevations, with the motors high enough to avoid the danger of flooding. This objective may often be secured with close-coupled units in which the motor is supported by a cradle resting on the pump or its foundation.

Priming. The opportunity to set the vertical pump at a low elevation with respect to the motor permits self-priming in many installations where it would otherwise not be possible. Sometimes vertical pumps are used even when priming is necessary. Horizontal double-suction pumps frequently require continuous venting or vacuum exhausting of air from the tops of the suction chambers.

Suction conditions. The double-suction pump has an advantage over the single-suction type in the matter of suction conditions as related to speed of rotation. The specific speed and the suction specific speed vary as the square root of the capacity; because the double-suction pump is, in effect, two single-suction pumps, each with half the total capacity, at a given rotation speed the specific speed for each is considerably lower than for a single suction pump with double the capacity. Were it not for the shaft through the eye of the double-suction impeller, the ratio of double-suction to single-suction permissible specific speeds, under comparable conditions, would be 1.414:1. The shaft through the eye, however, results in narrowing the difference in permissible specific speeds. Even so, the double-suction impellers can handle lower net positive suction heads than the single-suction impellers. The vertical pumps can sometimes be set low enough so that this disadvantage in suction head conditions is more than offset and thus higher speeds can be used. This leads to less expensive pumps with smaller and cheaper higher-speed motors.

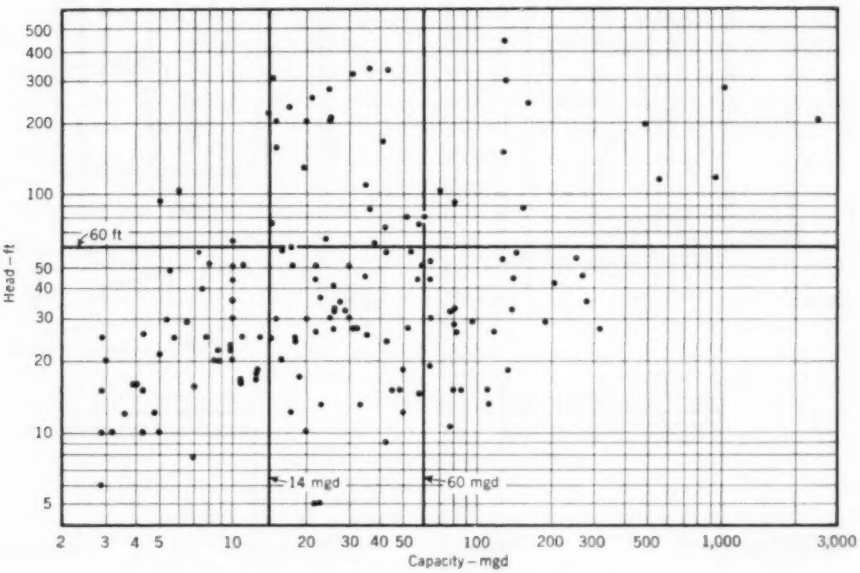


Fig. 2. Vertical-Pump Applications

The distribution, by head-capacity zones, of vertical end suction pump applications is shown.

Piping arrangement. Vertical end suction pumps lend themselves to the simplest possible piping arrangement, with entrance straight into the eye of the impeller from suction headers or suction wells below the pump floor. In the arrangements shown in Fig. 3,

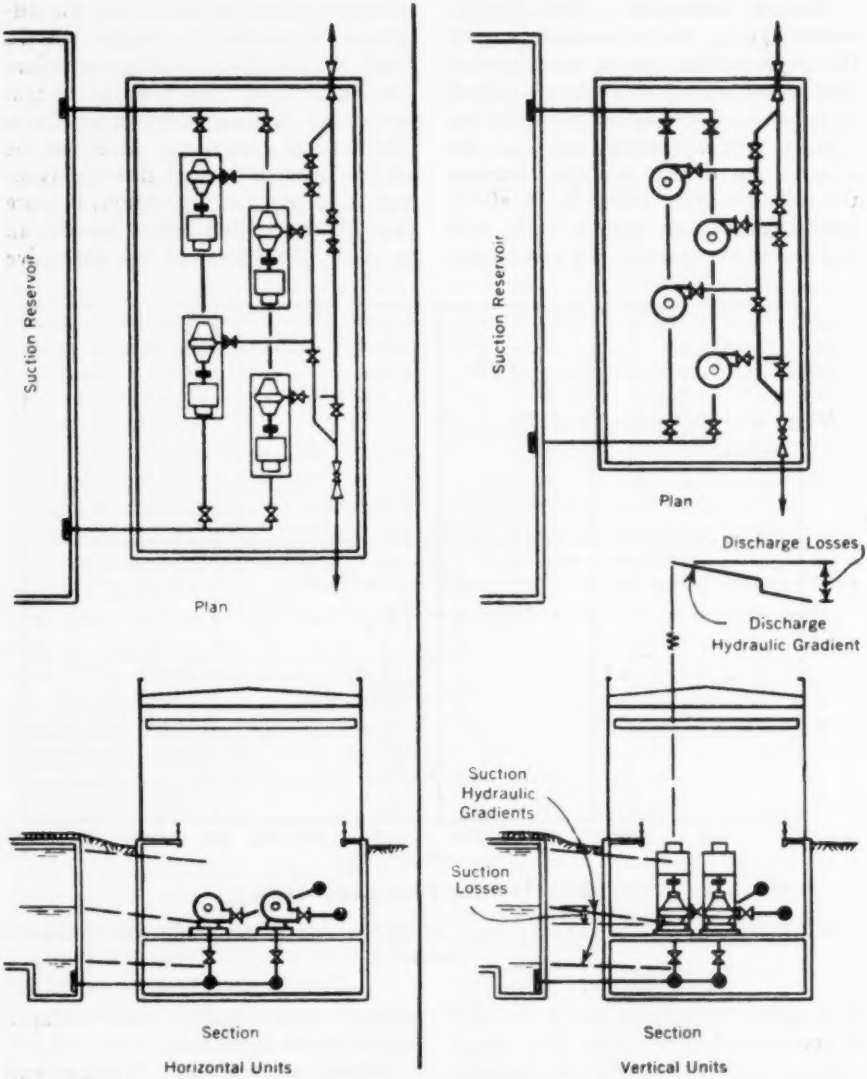


Fig. 3. Typical Pump Installations

This comparison of horizontal and vertical units demonstrates the space-saving advantage of the latter.

horizontal double-suction pumps with water entering from the bottom also provide simple, direct piping, although, once the water reaches the suction nozzle, the path becomes tortuous as it approaches the impeller. Frequently,

however, double-suction units have side suction and discharge openings with elbows close to the pump, resulting in additional losses that may have an important detrimental effect on overall pumping station efficiency.

Equipment cost. Vertical end suction pumps are considered "special" by a number of manufacturers and, at least in the smaller sizes, are more costly than the horizontal double-suction pumps already developed. There is some evidence that the cost spread between the vertical and horizontal units has been decreasing in recent years. Actually, vertical end suction pumps are so much simpler in design and construction that their cost should be less regardless of size, once the development and pattern work has been done. The vertical pumps have much simpler castings for both the casing and the impeller, fewer impeller surfaces, fewer shaft sleeves, and fewer packing assemblies. The shafts, although made larger in order to carry the overhung impellers, are simpler in construction. Vertical motors cost more than horizontal motors, but aside from this, it appears logical that the vertical units should be less costly than the double-suction horizontal units. Vertical motors will probably always cost more than horizontal motors of the same rating because of structural problems, bearings, and lubrication. In the smaller sizes, the availability of vertical motors is almost as good as that of horizontal motors. In the larger sizes, the motors are usually custom built for either vertical or horizontal use. All things considered, there should be little, if any, difference in the cost of vertical and horizontal pumps and certainly not enough to offset the saving in building costs provided by the former.

Maintenance. Those who favor the double-suction horizontal pump for water works service stress ease of maintenance as an important factor in selecting the split-case design. Actually, with a close-coupled vertical unit the impeller of which can be removed through the top head opening, disassembly and reassembly are relatively easy and convenient. There appears to be no reason why maintenance costs for vertical end suction pumps should be any higher than, or even as high as, for double-suction horizontal pumps, with the possible exception of extension shaft installations. In any event, disassembly is needed only at infrequent intervals.

Efficiency. As to efficiency, the more direct suction and simpler impeller with larger waterways would seem to favor the end suction type. On the other hand, the smaller eye diameter and longer advance through the impeller may favor the double-suction type. In practice to date, the efficiencies appear to be about the same for the two types.

Reliability. To quote one of the pump manufacturers, "A dry-pit installation of vertical pumps, with the bearings oil or grease lubricated, can be just as reliable as the horizontal double-suction unit."

Shaft deflections. In horizontal double-suction pumps with the weight of the rotating parts supported between widely separated bearings, some shaft deflection and stress reversal during rotation will occur. There is some recorded evidence that, because of such deflections, wearing ring clearances must be slightly greater for horizontal than for vertical pumps. According to MacDonald (*1*), "If the clearance is too small, the rings will contact during

operation and either seize or wear. This is particularly true with horizontal pumps in which the shaft must span a considerable distance between bearings and, in addition to carrying the weight of the impeller and sleeves, must resist some thrust resulting from the reaction of the water in the casing." Discussing an installation having a ring clearance of 10 mils, MacDonald stated: "This was found quite satisfactory for the vertical . . . units, but the horizontal pumps . . . could be operated only a few minutes before the power input began to increase. When the pump was shut down, it was found that the rings had seized. The clearance in these rings then was increased to 13 mils, and no further difficulty was experienced."

On the other hand, although, with proper static and dynamic balancing, the weight of parts cannot cause deflection in a vertical shaft, hydraulic thrusts normal to the shaft may do so. This fact, together with critical speed requirements, has led to the use of relatively large shafts in vertical pumps.

Thrust. Under the balanced hydraulic conditions in a double-suction unit, axial thrust is very low and the thrust bearing need not be of high capacity. In the vertical unit, the entire load of the rotating parts must be carried by a thrust bearing, and, in some of the low-head units not provided with upper wearing rings, the hydraulic thrust must also be carried. The higher-head units have top wearing rings and a balancing pipe to equalize the pressures above and below the impellers. Occasionally the top wearing rings are made larger in diameter than the bottom wearing rings, to give a lifting hydraulic thrust that counterbalances a portion of the weight of the rotating parts.

Bearings. Guide bearings for vertical units carry no appreciable load, whereas the horizontal shaft bearings are continuously loaded on one side only. Dependable thrust bearings may be obtained for a wide range of load and speed conditions. For vertical loads, they have the advantage of uniform load distribution around the entire circle. In a close-coupled pump with rigid shafting, the entire thrust may be carried by a single thrust bearing at the top of the motor. With this construction, three bearings for the pump and motor, or sometimes two bearings, may be used. Where flexible extension shafting is used, separate thrust bearings are provided for the pump and the motor, and there are two pump bearings, as well as two motor bearings, with intermediate shaft guide bearings as required.

Lubrication. Owing to the need for positive oil circulation with vertical bearings, the lubrication design of vertical pumps is somewhat more intricate than that of horizontal pumps but need not be elaborate or expensive in comparison to the overall cost.

Wearing rings. Apparently wearing ring clearances need not be greater, and may, perhaps, be smaller, in vertical than in horizontal pumps. In any event, with proper design of the shafts and bearings and with proper assembly, ring clearances for either type can be reasonably close.

Packing. The vertical end suction pump, with a single packing assembly, appears to have some advantage in packing. On the other hand, some say it is easier to maintain the packing adjustment in the horizontal units, possibly because of inconvenience of access to the vertical packing box.

Most of the minor points of comparison appear to present no controlling

advantages for one type or the other. The most important differences—[1] lower total cost of building plus equipment, and [2] location of pumps at low elevations for priming with motors at high elevations for protection against flooding—are in favor of the vertical pumps.

Vertical-Pump Installations

All of the very large installations are vertical end suction units. A few examples may be mentioned. Five Colorado River Aqueduct pumping stations, each equipped with three 130-mgd units, operating at heads up to 444 ft, were built 20 years ago. These installations are now being expanded by the addition of two more duplicate units in each station. The Granby, Colo., irrigation and power pumping plant, recently completed for the U.S. Bureau of Reclamation, has three 130-mgd units working at 186-ft head. Two units, each of 162-mgd capacity at 240-ft head, were installed in 1926 at the Rocky River station in Connecticut for water storage use. The new Tracy pumping plant of the Delta-Mendota Irrigation Project in California has six units, each rated at 496 mgd at 197-ft head. At Buchanan Dam, near Graphite, Tex., the Lower Colorado River Authority has recently installed, for offpeak pumping to storage, a unit of 560-mgd capacity at 115-ft head. A leading American manufacturer has furnished pumps delivering 970 mgd at 118-ft head for use in Brazil. The largest pumps now in operation are believed to be those at Grand Coulee, Wash., delivering 1,040 mgd each at 280-ft head, for irrigation use.

In hydroelectric practice, nearly all of the large reaction turbine generator units, which are comparable to pumping units in reverse, have been vertical-shaft, bottom outlet units. A leading pump manufacturer is now building a reversible motor and pump or turbine and generator unit for the TVA Hiwassee Project. Using a Francis type runner, this unit will, when operating as a motor and pump, have a rated capacity of approximately 2,500 mgd at 205-ft head. The runner is approximately 22 ft in diameter and the required motor output will be 102,000 hp.

Most of the foregoing examples are not water works installations, but there are many vertical-shaft end suction water works pumps in the 15–50 mgd capacity range. Grand Rapids, Mich., has had five high-service units in operation since 1939, as well as eight low-service units installed in 1928.

Perhaps the largest vertical-pump installation now in operation in water works service is that at the Bryant Street distribution pumping station in the District of Columbia. This new installation consists of three low-service units, each delivering 35 mgd at 45-ft head; three first high-service units, each delivering 35 mgd at 110-ft head; two second high-service units, each delivering 25 mgd at 210-ft head; and two third high-service units, each delivering 15 mgd at 310-ft head; making a total installed rated capacity of 290 mgd. All of these units are close coupled, with motors carried by cradles resting on the pump casings. The suction arrangement is such that water from either or both of two suction headers enters a vertical, converging suction pipe leading straight into the pump from below. In this project, the problem was one of remodeling a station nearly 50 years old. The use of vertical close-coupled pumps greatly facilitated the design and construction.

In the new water works pumping station at Niagara Falls, N.Y., ten vertical end suction close-coupled units are ready for initial operation. Four of the units, used for low-lift, raw-water pumping, are of 15, 20, 25, and 30 mgd capacity, all at 30-ft head. The high-service installation includes two units at 15 mgd, three at 20 mgd, and one at 25 mgd, all at 205-ft head.

Now under design and almost ready for construction is the new Dalecarlia Pumping Station of the Washington Aqueduct, supplying filtered water to Washington, D.C. The pumproom of this station will be approximately 200 ft long and 60 ft wide. Fifteen close-coupled vertical end suction units are to be used, consisting of: three low-service units, each 50 mgd at 50-ft head; three first high-service units, each 35 mgd at 145-ft head; three second high-service units, each 20 mgd at 225-ft head; and six third high-service units, each 27 mgd at 300-ft head. The total installed rated capacity will be 477 mgd. The pumps are in three rows, each served by a suction conduit supplied from both ends. Motors will be individually water cooled, and the entire building, most of which will be below ground level, will be air conditioned.

In addition to the new filtered-water pumping station at Dalecarlia, a low-head, raw-water booster station using vertical end suction pumps has been in substantially troublefree operation for many years. A new raw-water pumping station to supply water from Little Falls on the Potomac to the Dalecarlia Reservoir is now being designed. The initial installation will include five vertical end suction units, four delivering 100 mgd each and the fifth 50 mgd, all at approximately 120-ft head. Space will be provided for a sixth unit.

Gary, Ind., has four low-service units of the vertical end suction type, each rated at approximately 22 mgd at 50-ft head. The motors are set high above the pumps for security against flooding. The high-service units at Gary consist of four double-suction centrifugal pumps with the shafts set vertically, each delivering approximately 20 mgd at 160-ft head, with motors mounted on barrel supports 15 ft high to avoid the danger of flooding. Although these pumps are not of the end suction type discussed in this paper, the installation is mentioned as an excellent example of the use of this type of equipment.

Louisville, Ky., has two vertical end suction units of 30 mgd each at 205-ft head. Dallas, Tex., has three which deliver 18 mgd each at 275 ft. A number of other examples could be listed.

A firm in Scotland has developed and is regularly manufacturing a line of vertical close-coupled end suction units covering a capacity range from less than 1 mgd to 40 mgd or more at heads up to 300 ft or more. These units have welded steel casings, overhung impellers, a single shaft for motor and impeller, and two bearings. Twelve of them, ranging in capacity from 4 to 40 mgd, have been purchased by the Metropolitan Water Board to supply water in the London, England, area. The construction is simple and the costs are understood to be relatively low. Good efficiencies are obtained.

Various general arrangements and assemblies of vertical units are possible. If it is necessary to place the motors at an unusually high elevation with respect to the pumps, extension shafting with separate motor supports may be used. Often, however, the motor may be supported directly on the pump by

means of a cradle, and even then the motor is better protected against flooding than is a horizontal unit with the pump at or near the same elevation as the vertical pump. Long extension shafts may be troublesome. For large units, rigid couplings are best and present no problems in close-coupled construction. With long, solid shafting, however, building settlement or temperature changes may result in alignment difficulties. Universal shafting works well for long line shafts up to approximately 300 hp.

Use of Horizontal Pumps

There are, of course, a good many places where, owing to limitations of head room or for other reasons, horizontal units should be used. If, for instance, the suction and discharge arrangements are such that the installation calls for straight suction pipes above the floor entering the pumps from one side, and straight discharge pipes leaving the pumps on the other side, horizontal side suction units may be in order. Where the pumps are to be driven directly by internal-combustion engines, or by steam turbines through reduction gears, horizontal units may be preferable. Vertical units, particularly in the smaller sizes, may be driven by horizontal engines using angle gears.

The chief reason that, in the high-head, low-capacity application zone, horizontal double-suction pumps are used almost exclusively seems to be economy. For small sizes, cost savings in the purchase price of the equipment have been considered controlling and possible savings in building costs have been ignored or have not been regarded as sufficiently large to warrant special pumping unit development and manufacture. A representative of one of the leading manufacturers, who favors horizontal pumps, states that ". . . the logical position of a pumping unit is with a horizontal shaft and, if it were not so, the hundreds of pump manufacturers would not have made their patterns accordingly." A representative of one of the other leading manufacturers states: "Generally speaking, the horizontal pump attained a prominent position in the water works field through the use of steam turbine drives operating at high speed with gear reducers."

The author believes that the general acceptance of horizontal-shaft pumps may, to a degree, be a carryover from the earlier history of rotating machines, starting with the first wheeled vehicles and continuing through propulsion for boats and ships (whether paddle wheels or screw propellers), railroad rolling stock, automobiles, and even aircraft engines. Early steam engines had horizontal shafts and most industrial machinery uses horizontal shafts. The earliest and simplest bearings were horizontal. As electric motors were developed to drive machinery, it was logical that they be made readily adaptable to horizontal shafts. Some of the earliest centrifugal pumps, using steam engines for power, had rope or belt drives which favored the horizontal-shaft position. Vertical well pumps, on the other hand, being of such nature that vertical shafts had to be employed, came quickly into general use.

Conclusion

The idea that centrifugal pumps should be horizontal may be understandable, but is not necessarily logical. Actually, there is no question that vertical end suction pumps are entirely

satisfactory in the high-capacity zones for both low and high heads; that they are entirely satisfactory in the intermediate-capacity zones for both low and high heads; and that they are entirely satisfactory in the low-capacity, low-head zone. With the established record of satisfactory use in all of these areas of application, there would appear to be no reason to question the suitability of such pumps for the one zone in which to date they have had very little use—namely, capacities under 14 mgd at heads higher than 60 ft.

It is generally true that the so-called consulting or practicing engineers who design the pumping stations are not pump designers, and the author is no exception. In presenting the argument for vertical end suction pumps, it may be that this paper steps too far over the boundary into the field of the pump designer. The pump designers and manufacturers, however, are capable and resourceful, and it may be expected that, as water works men express a desire for the availability of vertical pumps for all single-stage applications, such pumps will be designed and built.

Reference

1. MacDonald, N. G. Modern Trends in Pumping Station Equipment. *Jour. AWWA* **34**:1241 (Aug. 1942).

Accident Rates in Utilities, 1952

The National Safety Council has recently furnished the accident rates in the public utility industries in the United States for 1952. As in the past, the communications industry has the lowest frequency and severity rates in the utility field. Its excellent record is indicative of the results that can be obtained with a safety program conscientiously carried out. The water industry in 1952 made respectable reductions in both accident frequency and severity rates over 1951. This trend reflects the increased attention the industry has recently paid to safety. As interest gains momentum there is every reason to believe that downward trends will continue in the future.

The 1952 accident rates for the public utility industries follow:

Utility	1952 Rates		Per Cent Change From 1951	
	Frequency*	Severity†	Frequency*	Severity†
Communications	1.61	0.10	−10	+11
Gas	14.40	0.81	− 8	−22
Electricity	11.06	1.66	0	−17
Water	23.9	0.59	−20	−18

* Number of lost-time injuries per 1,000,000 man-hours.
† Days lost per 1,000 man-hours.

Motor Drives for Water Pumps

By M. C. Boggis and E. O. Potthoff

A paper presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich., by M. C. Boggis, Application Engr., and E. O. Potthoff, Application Engr., General Electric Co., Schenectady, N.Y.

TODAY electric motors are almost universally used in modern water pumping stations to drive both raw- and finished-water pumps. Such widespread use of electric motors for water pumping has highlighted the need for careful engineering study of each motor application in order to select the best motor drive from the many types available.

This paper is written in an attempt to provide in one place the information needed to conduct or, at least, to initiate such a study. It deals with both the objectives of drive selection and the types of motor drives available for pumping station use. Sufficient detail is given to provide engineers with information needed to select drives for most pump applications. It is also hoped that the paper will interest water works personnel who are concerned with the proper application of electric-motor drives.

Pump horsepower ratings for domestic and industrial service range from a few horsepower through 3,000 hp. Most of these pumps are horizontal and operate at 720, 900, or 1,200 rpm. Conclusions and remarks contained in this paper will be generally confined to machines falling within these limitations.

A motor drive normally consists of a motor and its control. In the average pumping plant, the motor starters are integrated into a lineup with power distribution apparatus. By so doing, the starters become more closely allied with the electric-power distribution system than with the drives. This paper will consider only those parts of the primary starters that play a part in drive selection. Also, all auxiliary control features, such as speed controllers, required by a drive will be considered. Components common to all drives will, however, be omitted.

Drive Selection Criteria

There are two equally important steps involved in drive selection. The first concerns the type of drive—whether to choose a constant-speed or an adjustable-speed drive, a squirrel-cage induction motor or a synchronous motor. The different features of drives must be examined and a selection made on the basis of suitability for the installation involved.

The second step is the selection of mechanical and electrical features of the drive, such as the type of motor enclosure and the motor voltage. These choices are generally independent of the type of drive selected.

In deciding on the type of drive to be used, the purchaser must bear in mind these objectives: [1] low cost, [2] suitable performance characteristics, and [3] simplicity and ruggedness of construction.

The costs of a drive involve both initial and operating expense. The former comprises the purchase price at the job site and the cost of installation, including all mounting features such as floor supports, wiring and conduit, and special rigging. All necessary components must be considered in this analysis, or else the comparison becomes meaningless. If two different types of drives are under study, all equipment not common to both must be considered in the price comparison. Components common to the two drives need not be considered for obvious reasons. Initial costs are usually easy to obtain for comparison purposes.

Operating costs, on the other hand, are generally much more difficult to ascertain and evaluate. They include the energy costs, demand charges and power factor billing penalties, repair and maintenance costs, and extra operational labor expense, if any. The great variation in utility billing practice makes it mandatory that the operating costs be calculated for the specific installation concerned. In determining power expense, the best approach is generally to obtain applicable rate schedules from the power company and work closely with its representatives to compute exact costs. Many rate structures are so complex as to require interpretation by power company personnel.

The benefits obtained by improving power factor must be evaluated realistically. There is little, if anything, to be gained by improving it unless, by so doing, the power bill is reduced, the power system freed for additional loading, or the voltage regulation improved. The costs of power factor improvement must, of course, be measured against the benefits gained.

Annual repair and maintenance costs are difficult to anticipate. Instead of making cost comparisons, it is usual to select the mechanically simplest drive, if all other factors are equal.

In general, the performance requirements of a drive are determined by the characteristics of the hydraulic system, the pump, and the electric-power supply. How close the motor drive characteristics come to matching these requirements is dependent on the skill of the engineer selecting the drive. Of course, the final selection may differ slightly from the ideal because of compromises with costs or mechanical simplicity. The characteristics of the drives to be scrutinized are: torques throughout the speed range, inrush current of the motor, and speed adjustment abilities.

Inrush current limitations, if any, are placed on the drive requirements by the power company in the interest of minimizing light flicker in residential feeders. Station designers occasionally limit inrush to minimize light flicker within the station. It is of paramount importance to water works management to start motors on full voltage, because this method involves less initial cost, less floor space for equipment, and greater simplicity. The legitimacy of the need for limiting inrush by using reduced-voltage starting equipment or by building special motors should be carefully considered.

In some installations, it may be desired to increase the flexibility of the pump by changing the speed of its drive. The adjustable-speed feature adds to the price of the drive and increases the mechanical complications. Even with these objections, the benefits gained may well outweigh the costs.

Simplicity and ruggedness of construction of all apparatus installed in water works are of the utmost importance. The degree of simplicity of the drive will affect the amount of maintenance and the difficulty of repairs. Another important point is that the simplicity and ruggedness of a drive will influence the attitude of management and operators toward the drive. A drive that causes excessive trouble becomes a thorn in the side of those responsible for its operation, while one that presents few problems in operation becomes a source of pride to all responsible for it.

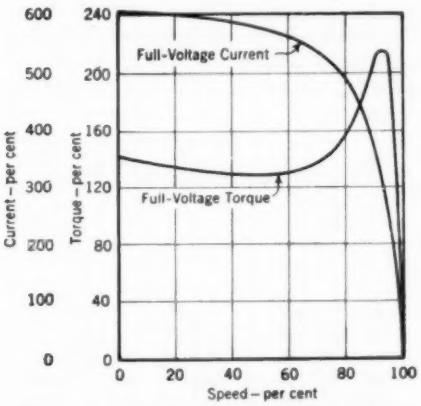


Fig. 1. Squirrel-Cage Induction Motor Characteristics

The curves show typical characteristics of a 300-hp, 2,300-v, 1,200-rpm squirrel-cage induction motor.

There are three general groups of motor drives for powering water pumps: [1] constant-speed motors; [2] multispeed motors; and [3] adjustable- (or variable-) speed motors.

Constant-Speed Drives

The constant-speed drive can be termed the workhorse of water pump drives. This reputation is earned because its low cost and simplicity are unrivaled. The benefits from these features are generally sufficient to overshadow the limitations caused by inflexible operating speeds.

The constant-speed motor class includes squirrel-cage induction motors, synchronous motors, and wound-rotor induction motors (when used for their starting characteristics only).

Squirrel-Cage Induction Motor

The squirrel-cage induction motor consists of a stator and a rotor. The stator or primary winding is a three-phase winding and is electrically insulated from the steel punchings that support it. The rotor or rotating element is equipped with an uninsulated, squirrel-cage type of winding, with the winding bars embedded in the steel punchings. The rotor requires no electrical connections to external apparatus. Wear points of the motor are limited to the bearings.

For control equipment, only a simple primary starter is required. The drive, therefore, becomes as simple mechanically and electrically as one can hope for. The simplicity of the drive will naturally result in low expected maintenance.

Typical torque-speed and current-speed relationships at full voltage for squirrel-cage induction motors are shown in Fig. 1. The percentage breakaway torque will generally vary inversely with the horsepower rating. Current inrush at full voltage will usually be approximately six times normal current. Some variation in inrush with different ratings can be expected, but, as a first approximation, the 6:1 ratio should be used.

The general-purpose motor design provides a good balance between inrush current, torque characteristics, operating power factor, and efficiency. When one factor is changed, all of the others are affected. When the inrush current is lowered by changing the motor design, the torque characteristics are affected and the operating power factor and efficiency decreased. Because the operating efficiency is generally of prime importance, it is a basically good practice to purchase the general-purpose squirrel-cage motor and lessen inrush, when necessary, by using a reduced-voltage starter. This method provides the desired starting characteristic without affecting normal running characteristics. As mentioned previously, however, the need for a reduced-voltage starting method should be carefully investigated.

The power factor of squirrel-cage induction motors depends essentially on the motor horsepower rating, speed, efficiency, and voltage rating. Table 1 shows full-load motor power factors that may be used in station design work. In general, power factors drop fairly rapidly with load. They may be boosted by connecting capacitors across the terminals of the motors. Approximate costs of capacitors are given in a later section of this paper.

TABLE 1

Full-Load Power Factors for Squirrel-Cage Induction Motors

hp	Full-Load Power Factors—*per cent*								
	v	440			2,300			4,000		
	rpm	720	900	1,200	720	900	1,200	720	900	1,200
50		84	86	88						
60		81	88	88						
75		82	86	88						
100		83	86	86						
125		86	87	87						
150		86	88	88	83.5	87	88			
200		86	88	88	86	87	88			
250		86	88	88	86	88	88	82	88	88
300		86	88	88	86	88	88	84	88	88
350					86	89	88	84	88	89.5
400					86	89	90	85	88	90
500					87	89	90	86	88	90
600					88	89	90	86	88	90
700					88	90	91	86	89	90
800					89	89	91	86	89	89.5
900					89	89	90	85	89	89.5
1,000					86	89	90	85	89	90
1,250					86	89	90	85	89	90

Synchronous Motor

The synchronous-motor drive consists of a motor, a source of d-c excitation, means of switching the source of d-c excitation to the rotor, and a pri-

mary starter. The stator is similar to that of the squirrel-cage induction motor. The rotor, however, is quite different, being equipped with field coils excited by d-c current supplied through slip rings. The rotor is equipped also with an intermittently rated squirrel-cage auxiliary winding (amortisseur winding), which develops torque just as it does in a squirrel-cage induction motor. The function of this winding is to accelerate the motor to substantially full speed.

The source of d-c excitation may be an exciter belted or connected directly to the motor, a separate motor-generator set capable of supplying power to one or several motors, or a metallic rectifier.

TABLE 2

*Standard Synchronous-Motor Torques**

hp	Speed *rpm*	Torque—*per cent*	
		Starting	Pull-in
1–200	1,800	110	110
1–200	1,200 or less	110	110
250–500	1,800 or less	110	110
501 or more	1,800 or less	85	85

* For motor speeds of 514 rpm or more, 60 cycles, and unity power factor.

Special field-synchronizing control equipment is provided to apply d-c excitation voltage to the rotor winding at the most advantageous time. The pull-in torque of a synchronous motor is the maximum constant torque under which the motor will pull its connected inertia load into synchronism, at rated voltage and frequency, when its field excitation is applied. After synchronization, the amortisseur winding plays little part in operation. The special control previously mentioned also provides thermal protection for the amortisseur winding; contains a means of detecting loss of synchronism of rotor and stator, with provision for stopping the drive; and has a switching function, so that the rotor field is discharged through a resistor during the acceleration period while not in use. All of this field synchronization equipment is supplied with the primary starter.

Synchronous motors may be obtained with a rated operating power factor of 1.0 or 0.8 leading. Considering the fact that the majority of other electrical apparatus in the water plant will be operating at a lagging power factor, some significance must be given to the synchronous motor's high operating power factor, which can effect a boost in the station's overall power factor. Thus, if the existing power rate structure takes into account the operating power factor, the power bill can be reduced.

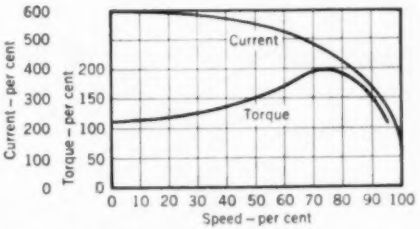


Fig. 2. Synchronous-Motor Characteristics

Typical characteristics are shown for a 500-hp, unity-power-factor, 2,300-v, 900-rpm synchronous motor.

From the foregoing remarks, one can conclude that the synchronous-motor drive is mechanically and electrically more complex than the squirrel-cage induction motor. The added components, such as exciter and field-

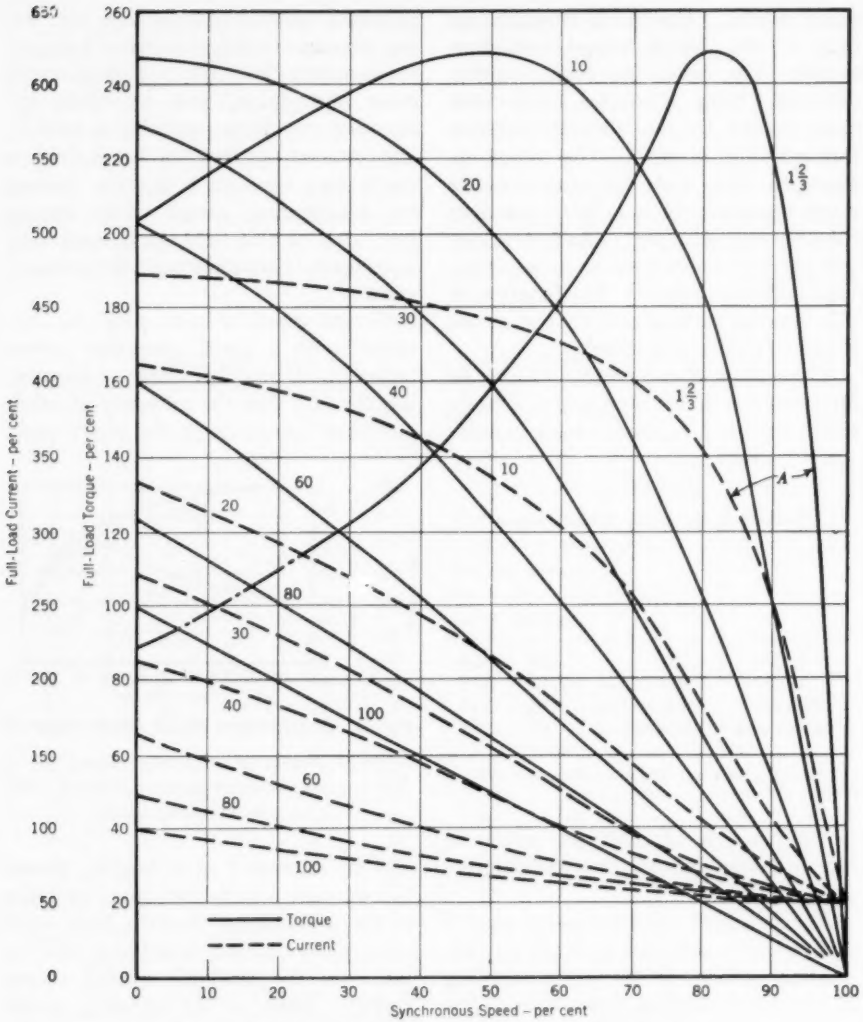


Fig. 3. Wound-Rotor Induction Motor Characteristics

Speed-torque (solid lines) and speed-current (broken lines) curves are shown. Curves marked A *are for the condition of no external resistance. The number next to each curve indicates the percentage of total resistance in the rotor circuit.*

synchronizing equipment, will increase the number of items requiring maintenance. Furthermore, the synchronous motor has a set of collector rings and brushes which also adds to the maintenance in comparison with normal squirrel-cage induction motor equipment. These disadvantages are, however, partially offset by the benefits of a larger air gap.

Industry standards for general-purpose, unity-power-factor, synchronous-motor torques are given in Table 2. As a general rule, it is preferable to adhere to these standards, but, if required, other torques can be supplied. Because the amortisseur winding is electrically separate from the main field winding, its design may be changed readily within limits, thus changing the starting and accelerating characteristics. Inrush current is directly dependent on the amount of accelerating torque required by the load. It is clear, therefore, that a realistic balance must be achieved in stipulating high acceleration torques and low inrush currents. The starting characteristics for a 500-hp, 900-rpm motor are shown in Fig. 2. It should be pointed out that the motor characteristics are guaranteed at normal voltage only. If the motor supply voltage drops during starting, or if reduced-voltage starting is used, full motor torques will not be obtained. The many complex problems of matching syncronous-motor starting characteristics to load requirements are beyond the scope of this paper.

Wound-Rotor Induction Motor

Wound-rotor induction motor drives are used for either adjustable- or constant-speed service. In this section, the drive will be considered for constant-speed service only and examined on the merits of its starting abilities.

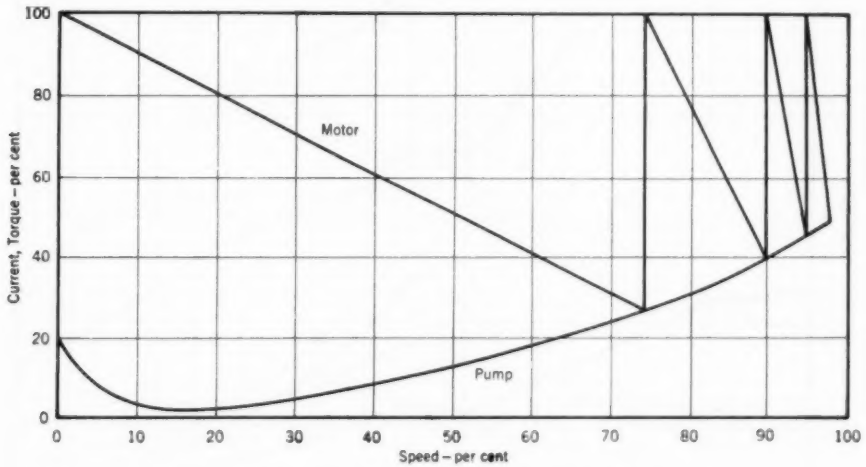


Fig. 4. Current-Speed Curve for Wound-Rotor Motor

Current and torque values are shown for a wound-rotor induction motor accelerating a radial-impeller pump with the discharge valve closed.

In addition to the motor and primary starter, a secondary controller and resistor are required to complete the drive. Its stator is essentially the same as that of a squirrel-cage induction motor. The rotor, however, is provided with insulated windings whose terminations are brought out to slip rings. In turn, the slip rings are connected to both the secondary re-

sistor and controller by cable. The operating characteristics of the drive are varied by adjustment of the external resistance in the secondary circuit.

The starting-torque efficiency of this drive is excellent. It develops approximately six times more torque per ampere than either of the other two types of constant-speed motors. The wound-rotor motor can usually accelerate a water pump to operating speed while drawing not more than 150 per cent of normal current from the line.

A characteristic curve for this type of motor is shown in Fig. 3. Variations in the motor torque characteristics are shown, each curve being identified by the percentage of total resistance in the rotor circuit. Figure 4 shows a current-speed curve for a wound-rotor motor driving a radial-impeller pump, with the discharge valve closed throughout the accelerating range and the motor drawing no more than rated current.

The wound-rotor induction motor is more complicated than the squirrel-cage type because of the addition of collector rings, brushes, and rotor winding insulation. In addition, the secondary controller will require some

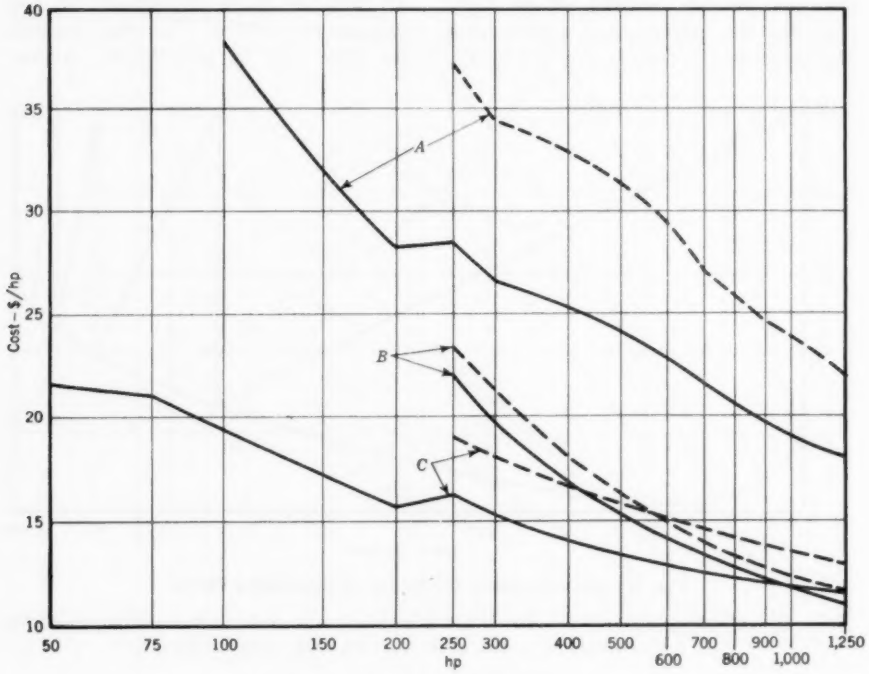


Fig. 5. Cost of 720-rpm Motors

Key: A—*wound rotor;* B—*synchronous;* C—*squirrel cage; solid line—440 and 2,300 v; broken line—4,000 v. Costs include necessary auxiliaries, except primary starters.*

maintenance, as it possesses several high-current-carrying contacts. This motor should be applied as a constant-speed drive only in the unusual instance when it is physically impossible to start either of the other two types of constant-speed drives because of stringent inrush limitations.

of constant-speed drives at three commonly used speeds. These cost figures, based on February 1953 prices, cover horizontal motors with standard enclosures only, as they are used in almost all instances. Although costs will change in time, it is not anticipated that the relationship between the

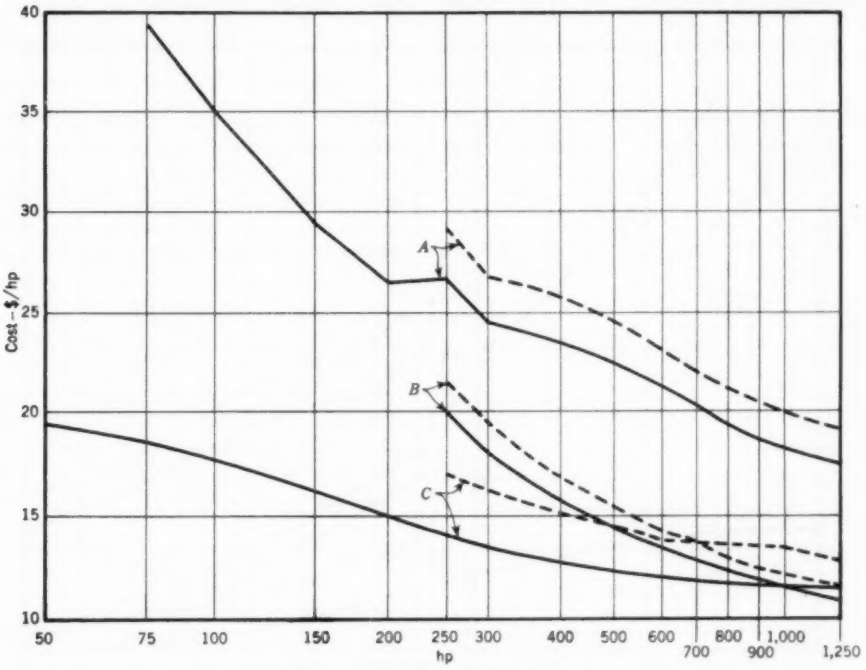


Fig. 6. Cost of 900-rpm Motors

Key: A—*wound rotor;* B—*synchronous;* C—*squirrel cage; solid line—440 and 2,300 v; broken line—4,000 v. Costs include necessary auxiliaries, except primary starters.*

Constant-Speed Drive Costs

The initial costs of constant-speed motor drives are dependent on the type, horsepower rating, voltage, and speed of motor and all special features, including the kind of mounting. The curves in Fig. 5–7 illustrate the effects of variations in horsepower rating and voltage on the prices of the three types

cost curves will vary appreciably. Total comparative prices of drives are obtained by multiplying the cost per horsepower of the drive by the horsepower rating.

For the squirrel-cage induction motor, these price figures include the motor price only. For the synchronous drive, a unity-power-factor motor

with direct-connected exciter and field application equipment is assumed. For the wound-rotor induction motor drive, prices include a motor with its secondary accelerating panel and resistor. The various types of drives are thus put on a comparable basis.

A study of these price curves will indicate the relatively low price of the squirrel-cage motors with ratings of 200 hp or less. If the synchronous-motor cost curves were extended into the smaller ratings, they would follow, generally, the costs of the wound-rotor induction motor at the same rating. The considerably higher price for the synchronous motor at ratings below 200 hp in the speeds under investigation makes its selection unattractive.

As ratings increase above 250 hp, the prices of the squirrel-cage induction motor and the synchronous motor slowly converge. The break-even point for the two drives is approximately 1,250 hp at 2,300 v or 700 hp at 4,000 v, in the speeds under consideration. As will presently be shown, the efficiency of the synchronous motor is appreciably greater than that of the squirrel-cage induction motor. It is, therefore, generally neces-

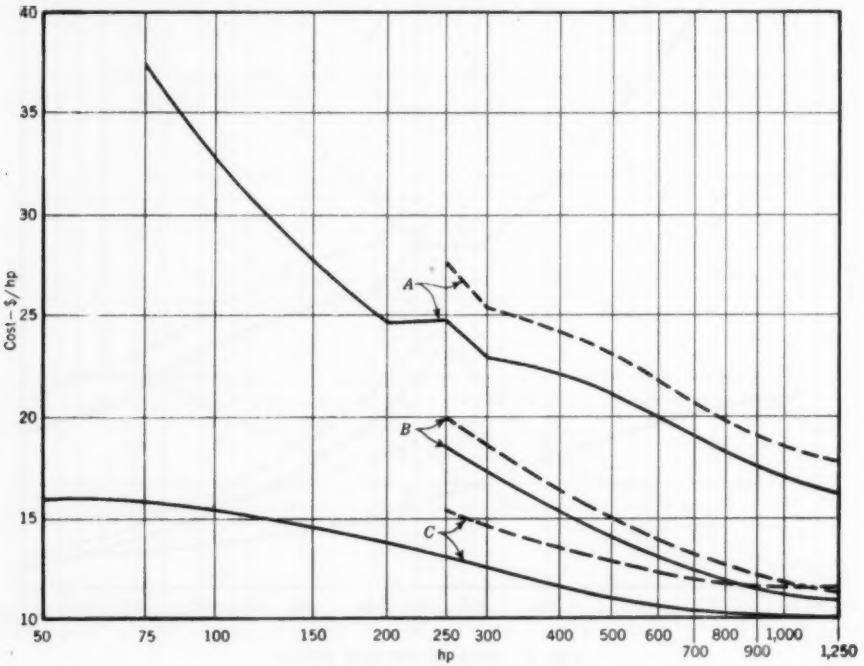


Fig. 7. Cost of 1,200-rpm Motors

Key: A—*wound rotor;* B—*synchronous;* C—*squirrel cage; solid line—440 and 2,300 v; broken line—4,000 v. Costs include necessary auxiliaries, except primary starters.*

sary to balance the higher cost of the synchronous motor against its lower energy, demand, and power factor costs. By and large, the synchronous motor starts to show important economic gains at roughly 500 hp, in the speeds under discussion. At ratings of 1,000 hp or more, substantially all constant-speed pump drives are of the synchronous-motor type.

Constant-Speed Drive Efficiencies

Efficiencies of drives vary with the type, horsepower, voltage, and speed rating. In vertical drives, very high thrusts may require the use of plate bearings, thereby increasing the thrust bearing losses and reducing the efficiency.

Figures 8–10 compare standard drive efficiencies at different horsepowers and speeds, for full load only. Exciter losses are included in the efficiencies for the synchronous motor. An examination of these curves will show the main advantage of the synchronous motor: its higher operating efficiency.

Typical Selection Problem

To illustrate some of the chief principles of drive selection and the use of data provided in this paper, a representative problem will be discussed. Assume that a water utility desires to purchase a horizontal pump to increase station capacity. The pump is expected to operate 5,000 hr per year at the existing utility power rate. The pump selected requires a drive rating of 500 hp at 900 rpm. A constant-speed type is selected as adequate. The station voltage supply is 2,400 v, three phase, 60 cycles.

Under the power rate schedule of the local electric utility, there is a demand charge of $1.50 per kilowatt per month. The energy charge is:

1.2 cents per kilowatt-hour for the first 50 kwhr per kilowatt billing demand

0.9 cents per kilowatt-hour for the next 100 kwhr per kilowatt billing demand

0.7 cents per kilowatt-hour for all over 150 kwhr per kilowatt billing demand.

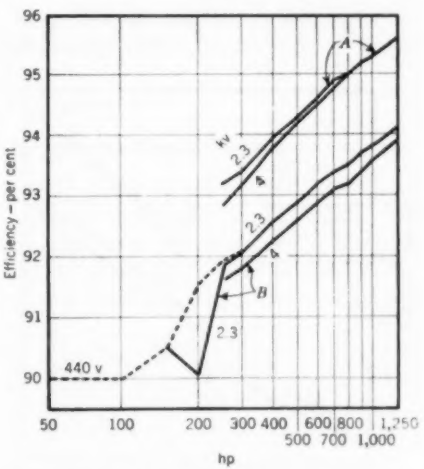


Fig. 8. Drive Efficiencies (720 rpm)

Key: A—synchronous motors (unity power factor); B—squirrel-cage induction motors.

The billing demand equals the peak kilowatt demand (for any 15-min interval) times 0.85 divided by the power factor.

The choice of drive would probably be limited to a squirrel-cage induction motor or a unity-power-factor synchronous motor. An inspection of Fig. 12 (see p. 1040) will indicate that 2,300 v is satisfactory as a motor voltage rating for this size of motor. For the

synchronous-motor drive, the price (less primary starter) is \$14.25 per horsepower (according to Fig. 6), making the initial cost of the drive $500 \times 14.25 = \$7{,}125$. As the efficiency of the motor at full load is 94.4 per cent (Fig. 9), the kilowatt demand would be $500 \times 0.746 \div 0.944 = 395$. Multiplying this figure by the average number of operating hours per month ($5{,}000 \div 12$) gives an average monthly use of 164,800 kwhr.

As previously defined, the billing demand is $395 \times 0.85 = 336$, when the power factor is unity. The billing demand charge is, therefore, $\$1.50 \times 336 = \$504$. The energy costs per month amount to \$1,307, so that the total monthly power bill is \$1,811 for the synchronous-motor drive.

The same general procedure may be used to determine costs for the squirrel-cage induction motor drive. It will be found that the initial cost of this drive is \$6,130—almost \$1,000 less than the synchronous motor—but the monthly power bill is \$1,913, a difference of \$102 in favor of the synchronous motor. To provide a useful basis for comparison, the power bill saving can be calculated in terms of present worth. Assuming a drive life of 20 years, the present-worth factor applying to the difference in power bills is 14.877. Then the present worth of the difference is $14.8 \times 102 \times 12 = \$18{,}100$.

If the higher power cost of the squirrel-cage induction motor is added to the initial cost of the drive, its price would be \$24,230, compared with \$7,125 for the synchronous motor. It is obvious that the synchronous motor has a considerably lower cost than the squirrel-cage motor and should be selected.

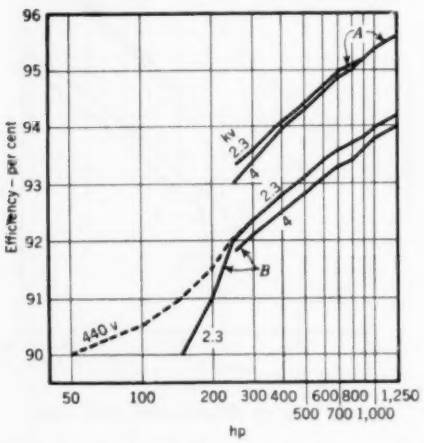


Fig. 9. Drive Efficiencies (900 rpm)

Key: A—*synchronous motors (unity power factor);* B—*squirrel-cage induction motors.*

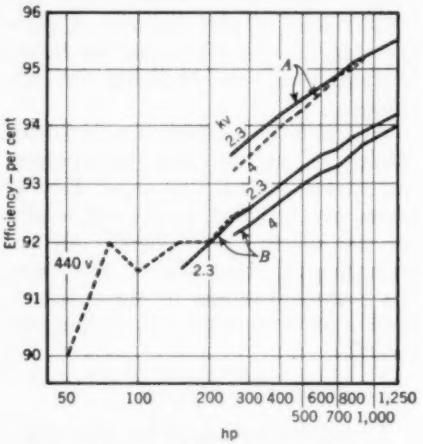


Fig. 10. Drive Efficiencies (1,200 rpm)

Key: A—*synchronous motors (unity power factor);* B—*squirrel-cage induction motors.*

Multispeed Drives

Multispeed drives serve as compromises between constant-speed and adjustable-speed drives. They are

characterized by their ability to operate at generally two and occasionally three or four speeds. When applied as water pump drives, either squirrel-cage induction or synchronous motors are used. The choice between these two types is made on the same basis as the choice between two single-speed drives. The drive may be built as one unit, consisting of a stator with two windings and one rotor, or as two separate machines coupled together. A primary switching device is required for each running winding of the motor.

A two-speed drive costs approximately twice as much as a single-speed drive of the same type, horsepower, and speed as the high-speed rating of the two-speed motor. The power factor at each operating speed will be roughly the same as that of a single-speed motor with the same speed rating as the higher speed of the two-speed motor. Although somewhat more complicated than a single-speed drive of the same type, the multispeed drive has proved mechanically successful in operation.

It must be clear that, from a drive standpoint only, there is no gain in the use of a two-speed motor instead of two constant-speed motors of the same type and rating, each driving a separate pump. The costs and performance of these two types of drive are approximately the same. The advantage of a two-speed motor is that only one pump is required, thereby decreasing cost and floor space. This benefit is obtained at the expense of reliability, however, as failure of any one component makes the drive unusable.

The main problem in applying multispeed motors is the difficulty in getting drive speeds that satisfy hydraulic requirements. Motor speeds are limited by the number of magnetic poles built into the stator. These synchronous speeds are 3,600, 1,800, 1,200, 900, 720, 600 rpm, and so on, for a 60-cycle system. Their fixed relationship leaves no margin for adjustment between synchronous speeds and requires close consultation between the hydraulic designer and the electrical manufacturer during the design stage of the station. In this way, the best speed combinations can be selected, thereby bringing benefits to the ultimate owner.

Adjustable-Speed Drives

Adjustable-speed drives are those capable of gradual speed changes over a considerable speed range. The number of operating speeds is determined by the type of speed control employed and the type of drive selected. The only reason for choosing this class of drive is to increase the flexibility of the pump.

The use of the wound-rotor induction motor has been so general as practically to exclude all other types of adjustable-speed drives for water pumps. Adjustable-voltage d-c drives, Scherbius, magnetic or hydraulic coupling–motor combinations, and brush-shift motor drives are used to advantage in various industries, but their general suitability does not equal that of the wound-rotor induction motor for driving water pumps. For that reason, this paper will discuss only the wound-rotor induction motor type of adjustable-speed drive.

The speed of a wound-rotor induction motor is adjusted by varying the resistance of the motor rotor circuit. The motor speed decreases with in-

creased load or increased rotor circuit resistance. The total rotor resistance must be increased to reduce speed. Hence, power losses in the resistor increase as speed is reduced, the maximum loss occurring at approximately 66 per cent speed, with a pump loading. Power losses decrease as the speed drops below this point. At maximum speed and normal torque, the efficiency is slightly less than that of the squirrel-cage induction motor. As speed is reduced, drive efficiency goes down, owing to resistor losses. Efficiency at the reduced speeds is equal to the product of the percentage of maximum speed and the efficiency at full speed with the same percentage of torque. Thus, for a motor operating at 80 per cent speed and 75 per cent torque and having a full-speed efficiency of 90 per cent at 75 per cent torque, the efficiency will be approximately 0.8×90, or 72 per cent.

The power factor of the wound-rotor motor is approximately that of the squirrel-cage induction motor at any particular torque load, regardless of the speed setting. Thus, the power factor of the wound-rotor motor operating at 80 per cent of normal speed and 75 per cent of normal torque is approximately equal to the power factor of the squirrel-cage induction motor at 75 per cent of normal torque. The full-load power factors of wound-rotor induction motors in common ratings are given in Table 3.

TABLE 3

Full-Load Power Factors for Wound-Rotor Induction Motors

hp	Full-Load Power Factors—*per cent*								
	v	440			2,300			4,000		
	rpm	720	900	1,200	720	900	1,200	720	900	1,200
50		80	81.5	85						
60		82	83	86						
75		80	85	87						
100		83	85	88						
125		84	86	88						
150		84	87	88	81	86	87			
200		84	88	88	82	87	87			
250		84	87	88	84	87	87	80	86	86
300		84	87	88	84	87	86	80	86	86
350					86	87	86	80	86	88
400					86	87.5	89	82	86	88
500					86	86	89	83	86	88
600					86	86	89	83	86	88
700					86	88	89	83	87	88
800					86	89	88	85	87	87
900					86	89	88	85	87	87
1,000					86	89	88	85	87	87
1,250					86	89	88	85	87	87

As a general rule, the cost of a wound-rotor motor drive is double or more the price of the least expensive constant-speed drive of equal rating,

or roughly the same as that of a two-speed motor with a rating equal to that of the high-speed winding. The cost will vary considerably with the selection of different types of secondary controllers.

Three types of secondary controllers are used with wound-rotor motors: drum or cam switches, magnetic controllers, and liquid rheostats. Cam switches are motor operated and constructed for either thirteen or twenty points of operation. Drum switches are generally worked manually and have eleven points of operation. Two points of each are generally used for acceleration, and the others for speed regulation. Either an operator or a pilot motor rotates the switch, thereby closing or opening contacts and increasing or decreasing rotor circuit resistance. The motorized cam switch is preferred to the manual drum switch because acceleration is controlled automatically and no damage to the drive is likely from incorrect accelerating operations.

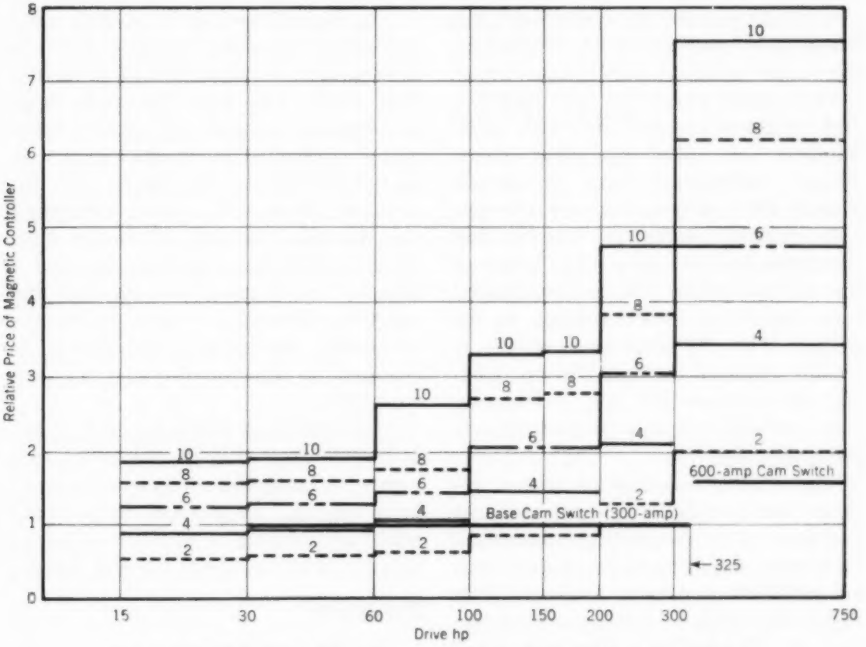


Fig. 11. Relative Costs of Magnetic Controllers and Cam Switches

The 300-amp cam switch price is considered to be unity. The numbers on the curves indicate the number of regulating steps for the magnetic controllers. If, for a given horsepower rating, two prices are indicated for the same number of regulating steps, the lower price applies.

Magnetic controllers may be built with any number of accelerating and regulating steps. The magnetic con-

troller functions by closure of contactors to vary resistance in the motor rotor circuit. The cam switch and magnetic controller described are of very rugged construction and are well suited for use in water pumping service.

The choice between these two types of controllers depends on the horsepower rating of the drive and the number of speed points desired. Figure 11 shows the relation between prices of thirteen-point motorized cam switches and magnetic controllers with even numbers of speed-regulating steps. These comparisons are based on March 1953 prices, but any changes will probably leave the relationship substantially the same. The price of the thirteen-point, 300-amp motorized cam controller is considered to be unity. The 300-amp cam switch is usually required through 300 hp; from 350 hp through 750 hp, a 600-amp cam controller (price factor 1.6) is generally used.

The magnetic-controller prices include two accelerating contactors in addition to the regulating contactors. Only even numbers of regulating steps are included, and each combination of regulating steps is indicated by numbers in the figure. The two-speed magnetic controller may be omitted from further consideration, as usually the two-speed motor can be employed to better advantage.

The curves may be used in the following manner: Considering a 250-hp motor with four regulating steps, the magnetic controller costs 2.1 times the price of the thirteen-point cam switch. For a 500-hp drive operating with four speed points, the magnetic controller would cost $3.4 \div 1.6 = 2.1$ times the price of the thirteen-point motorized cam switch. A motorized cam switch is generally recommended if the magnetic-controller price for the number of speed points at the given horsepower rating is 2.0 per unit or more. If the price is less than 2.0, a magnetic controller is advisable.

Secondary-resistor prices are not considered as they are common to both controllers.

The liquid rheostat is seldom used as control for water pump motors; it is employed to some extent in industrial work, but only for very large horsepower ratings. A wound-rotor motor controlled by it can operate at an infinite number of speeds. It consists of three cells, each containing one movable and one stationary electrode, a tank housing the cells, and a driving mechanism to operate the movable electrodes. An electrolyte inundates the cells. Resistance is changed by varying the gap between electrodes.

The initial cost of the liquid rheostat is higher than that of the other two forms of controllers, except for very large drives. In general, it is worth while considering a liquid rheostat in drive ratings of 1,000 hp and larger.

Enclosures

The type of enclosure for a pump motor depends mostly on the location of the drive. For indoor service, several different types of enclosures are available: open, dripproof, splashproof, and totally enclosed. The open type of enclosure is rapidly losing its general appeal because it fails to safeguard the motor against damage from hand tools and dripping water coming in contact with the windings. The dripproof enclosure gives the machine this protection and is recommended for mounting indoors. Neither the splashproof nor totally enclosed type

of construction has been found necessary for indoor machines.

In the last few years there has been a trend toward the construction of outdoor pumping installations, in the interest of saving housing costs. Motors located outdoors must be provided with suitable enclosures to protect the windings against moisture. The entry of moisture into insulation will reduce the turn-to-turn and turn-to-ground insulation and introduce the possibility of an electrical breakdown. For outdoor installations, the enclosure that will best protect the windings from moisture is a totally enclosed one of the fan-cooled, surface-cooled, or nonventilated type. The totally enclosed, fan- or surface-cooled design is used except in very small ratings. A so-called weather-protected motor that helps protect the motor windings from moisture by careful baffling has been developed. Only the totally enclosed or weather-protected types should be considered for outdoor service, with the possible exception of irrigation service, in which favorable weather conditions normally prevail. The purchaser should weigh fully the possible effects of repeated repairs and outages that may result when an inadequately protected machine is used in outdoor service. Furthermore, the higher the voltage used, the more likelihood there is of breakdown and subsequent damage from rainstorms.

Bearings

The choice of ball or sleeve bearings in horizontal machines depends mostly on the experience and practices of water works operating groups. In vertical machines, the type of thrust bearing plays a smaller part in selection than does suitability of application. For normal thrust values, the ball bearing can be used to advantage. In an intermediate range, the roller bearing can be used. For the higher thrust values, the plate type of bearing must be employed exclusively. The lower guide bearing may be of ball or sleeve construction. It is usually highly advantageous to use a split-sleeve bearing for the lower guide in large drives, as the bearing can be replaced without pulling out the motor rotor.

Motor Insulation

Standard types of Class A organic insulation are satisfactory for general use in pump drives. These insulations may operate in ambients not exceeding 40°C and with hot-spot temperatures not exceeding 105°C. The record of this classification of insulation in service is excellent.

In wet installations, such as underground stations, where there is an abundance of free water and the relative humidity is high, extra varnish dip and bake treatments may be given the motor windings to good advantage if the motor is not idle more than approximately 10 days. The extra varnish tends to improve the sealing of organic papers and cloths used as insulation, thereby reducing the rate of moisture absorption.

It is important that motor windings remain dry so that the chance that operating voltage will break down the insulation is minimized. While a motor is operating, sufficient heat is developed to prevent condensation of airborne moisture. When the machine is idle, no heat is generated in the motor and, therefore, some additional source of heat should be applied to the motor if high-humidity conditions prevail. One common method used for both low- and medium-voltage motors is to

mount electric space heaters in the motors. The heaters are energized automatically from a lighting circuit when a motor is idle.

Another method, used for heating low-voltage motors only, is to apply a very low voltage across a single phase of the motor circuit while the motor is inoperative. Sufficient heat is generated in the motor by this circulating current to provide necessary drying action. This method is highly effective, as the heat generated is immediately adjacent to the insulation—the place where heat is required.

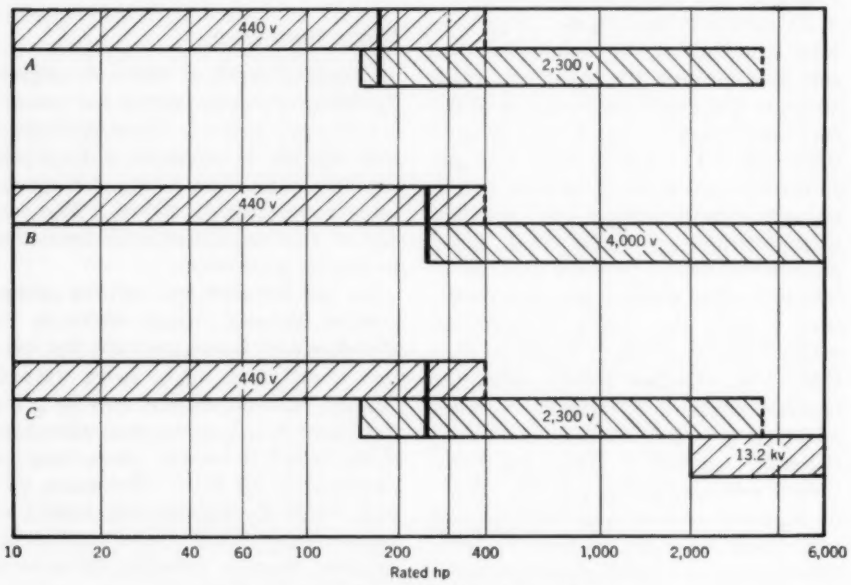


Fig. 12. Recommended Motor Ratings

Key: A—*2,400-v source;* B—*4,160-v source;* C—*13.8-kv source.*

Exciters Versus Motor-Generators

Cost is the determining factor in deciding whether a direct-connected exciter or a separate motor-generator set is to be used for the excitation of a synchronous motor. The significant items included in the cost of the motor-generator are the motor control, the extra power wiring and conduit for the driving motor, any additional supply transformers for it, any distribution switchgear required for the set, and handling and mounting. Almost invariably the direct-connected exciter has a decidedly lower initial cost than the motor-generator set, although the cost increases as the speed is reduced. Moreover, direct-connected exciters overhung from motor shafts possess no bearings and so are a simple form of rotating equipment.

To illustrate, for a 500-hp, 900-rpm, 2,300-v synchronous-motor drive, a direct-connected exciter would cost $630. A separate motor-generator set would cost $690, plus an estimated

$345 for handling and mounting, $60 for a motor starter, and an estimated $30 for a supply transformer, totaling $1,125. This figure does not include the cost of extra switching elements or dual power sources commonly used. These added costs would bring the total to a substantially higher level.

Recommended Motor Voltages

Of the many motor voltage ratings available—including 208, 220, 440, 550, 2,300, 4,000, 4,600, 6,600, 11,000, and 13,200 v—the most commonly used are 440, 2,300, 4,000 and 13,200 v, which correspond to power system voltages of 480, 2,400, 4,160 and 13,800, respectively. There is no precise rule for selecting the voltage to operate water plant motors, because horsepower ratings will vary from plant to plant and even within plants.

In an integrated plant built for treating and pumping water, more than one utilization voltage will be required. Small motors may be supplied from a bus at one voltage, usually 480, and large motors from another. Physical location and space and wiring problems must be considered in addition to optimum drive voltage.

Just what the additional higher bus voltage should be (between 2,400 and 13,800) and where it will be needed are the really difficult questions. Figure 12 provides a guide that takes into account effects on the whole electrical system beyond the narrow criteria of motor, transformer, and control prices and availability. Recommended motor voltages are shown against horsepower for several common system voltages. The length and position of the horizontal bars indicate suggested maximum and minimum motor horsepower for each voltage rating. The heavy vertical line in each section represents the horsepower rating at which the costs of the motors, including starting equipment and necessary substations, are equal for the adjacent voltage ratings.

As these graphs indicate, the minimum recommended motor horsepower at 2,300 v is 150; and at 4,000 v, 250 hp. The economic break-even point for motors with voltages of 440 or more, for any of the three systems discussed, lies between 175 and 250 hp.

The above voltage selections involve several considerations other than economy: the mechanical strength of motor windings, electrical characteristics of the motors, and margins of insulation strength. Although there are motors available as standard items which depart considerably from these general voltage limitations, they should not be construed as being recommended by the manufacturer. Such motors are offered to satisfy exceptional needs.

Lightning Arresters and Surge Capacitors

Considerable confusion seems to exist about how lightning damages rotating equipment and how available devices can protect these machines from damage. Surge voltages from lightning appear in overhead power lines, either through direct strokes or through induction from nearby discharges. Line potentials may be raised to several million volts by direct strokes or to perhaps 500,000 v through induced strokes. These dangerous surges, if unchecked, would shortly appear in the electric power system within the water station.

It is entirely uneconomical to build motors whose insulation is capable of withstanding high-voltage lightning surges. Strict dependence is placed

on station designers for protecting the motor by mounting lightning arresters and surge capacitors at proper points in the electrical system. Lightning arresters reduce the peaks of the surges by shunting a discharge current to ground. Thus, excess voltage is bled from the system, allowing the lowest practical overvoltage to pass the point of arrester application.

Even though the magnitude has been reduced, the surge, commonly known as a steep-front wave, will tend to concentrate a large part of the voltage across the first turn of a motor terminal coil instead of distributing it evenly through the winding. The voltage stress across this first turn can be hundreds of times higher than the normal operating voltage of the turn and may break down the insulation. This danger can be minimized by the addition of capacitors, which reduce the steepness of the wave and greatly decrease the amount of voltage impressed across the first turns. These capacitors differ from power factor improvement capacitors, and the two types must not be confused.

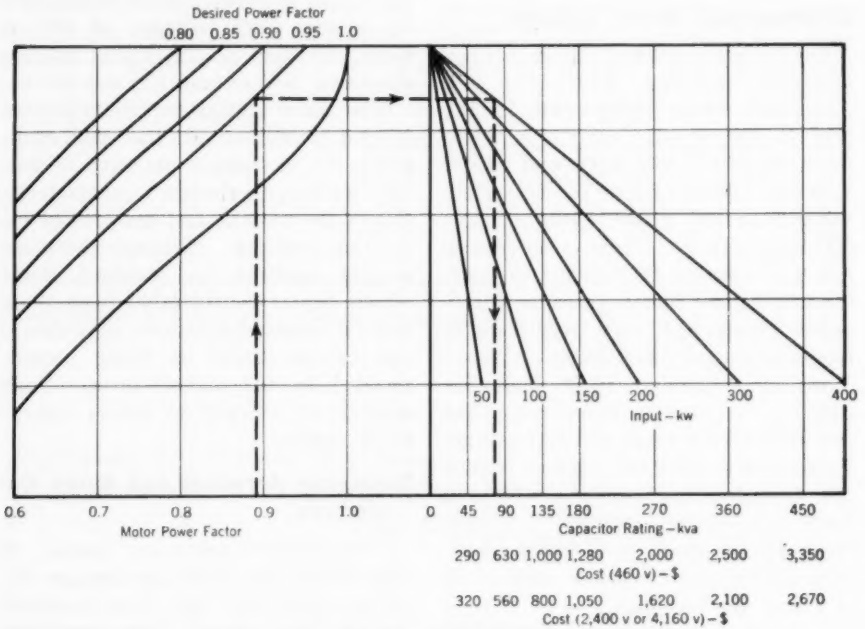


Fig. 13. Capacitor Ratings and Costs

The chart relates original motor power factor, desired operating power factor, motor kilowatt input, and capacitor ratings and costs. The chart is applicable for 60 cycles only. The broken line indicates the manner in which the chart is used.

Power Factor Improvement Capacitors

Power factor improvement capacitors may be connected across the termi-

nals of either squirrel-cage or wound-rotor induction motors. Whether or not the use of these capacitors will show an economic gain over the cost of investment will depend on the rating of the motor, the period of operation, and the power rate structure. As power rate structures vary throughout the country, it is impossible to state flatly that capacitors are or are not economical. It is possible, however, to show the approximate equipment costs for capacitors, so that those interested can judge for themselves in the light of their particular situation.

Figure 13 shows a relation between original motor power factor, a desired operating power factor, motor kilowatt input, and finally capacitor ratings and costs. These curves are based on March 1953 prices. The motor kilowatt input can be computed from the formula (horsepower and motor efficiency at full load only):

TABLE 4

*Maximum Capacitor Ratings**

Induction Motor Rating *hp*	Maximum Capacitor Rating—*kvar*†				
	Nominal Motor Speed—*rpm*				
	1,800	1,200	900	720	600
3	1.5	1.5	2	2.5	3.5
5	2	2	3	4	4.5
7.5	2.5	3	4	5.5	6
10	3	3.5	5	6.5	7.5
15	4	5	6.5	8	9.5
20	5	6.5	7.5	9	12
25	6	7.5	9	11	14
30	7	9	10	12	16
40	9	11	12	15	20
50	11	13	15	19	24
60	14	15	18	22	27
75	16	18	21	26	32.5
100	21	25	27	32.5	40
125	26	30	32.5	40	47.5
150	30	35	37.5	47.5	52.5
200	37.5	42.5	47.5	60	65
250	45	52.5	57.5	70	77.5
300	52.5	60	65	80	87.5
350	60	67.5	75	87.5	95
400	65	75	85	95	105
450	67.5	80	92.5	100	110
500	72.5	82.5	97.5	107.5	115

* Suggested maximum capacitor ratings when a 60-cycle induction motor and capacitor are switched as a unit, for normal starting torque, normal starting current, and National Electrical Manufacturers Assn. (NEMA) Classification Design Class B motor. Motors may be either squirrel-cage or wound-rotor type.

† Kilovolt-amperes reactive.

$$\text{kw input} = \frac{\text{hp} \times 74.6}{\% \text{ motor efficiency}}$$

The curves can be used as follows: Assume a squirrel-cage induction motor with a horsepower rating of 500 at 900 rpm and a voltage rating of 2,300 at 60 cycles. Assume that the power factor is to be corrected to 95 per cent at full load. From Fig. 9, motor efficiency is found to be 93.1 per cent and from Table 1 the power factor is found to be 89 per cent. The kilowatt input is $500 \times 74.6 \div 93.1 = 400$ kw. The broken line in Fig. 13 traces the path through the curves to a solution. Starting at the lower left, at 89 per cent original power factor, a line is run vertically to intersect the line denoting desired power factor. This point of intersection is projected to the right far enough to intersect the 400-kw input line. That point of intersection is then brought down to the lower right, where the capacitor rating and equipment cost are read directly. In this example, the nearest rating is 90 kva at a cost of $560. These figures do not cover any switching equipment for the capacitors.

One important point to note is that there is a limitation on the capacitor kilovolt-amperes reactive that can be connected across the terminals of an induction motor. This limitation, for most ratings, is shown in Table 4.

Conclusion

It is hoped that the material presented will be of assistance to the pumping station designer in realizing the objectives of low cost, suitable performance characteristics, simplicity, and ruggedness of pump drives. No simple formula has been disclosed that will remove the necessity for careful engineering study of each individual installation. It is believed, however, that the principles, practices, and conclusions given form a workable basis for the launching of such studies of new water pump drives.

Vertical Short-coupled Turbine Pumps

A. O. Fabrin

A paper presented on Sept. 16, 1952, at the Kentucky-Tennessee Section Meeting, Knoxville, Tenn., by A. O. Fabrin, Chief Engr., Layne & Bowler, Inc., Memphis, Tenn.

THERE is a definite trend from the horizontal to the vertical type of pump for use in public water systems, irrigation condenser systems, bilge and sump service, drydock and fire equipment, mine drainage, steel plants, and many other industries. These applications represent a very considerable field in which the horizontal centrifugal pump has served long and admirably and in which the vertical type of pump offers a challenge.

Some very large units of the volute type with vertical shafts have been installed, but the type of pump under consideration at present is the concentric-case unit used in deep wells. The rapid agricultural development of the arid and semiarid portions of the western United States can be largely attributed to progress in the use and improvement in the design of deep well pumps. For some time this type of pump has been accepted as a reliable machine for industrial projects and the public utility field. The modern version develops efficiencies as high as and sometimes higher than horizontal pumps. Consequently, it no longer is considered a special pump to be used only in deep settings where the impellers operate at an elevation below the suction limit of the horizontal pump.

The short-coupled vertical pump can be arranged for either underground or aboveground discharge. The general design is illustrated in Fig. 1. Prior to the war many small cities mounted vertical-turbine pumps directly over reservoirs, with the pumping element submerged in the water and discharging into the service mains. The pump is admirably adapted for such operations as booster cooling and circulating, ground drainage, air conditioning, caisson and mine dewatering, fire protection, and general-purpose pumping.

A few of the advantages of the vertical pump are:

1. A minimum amount of space is required for foundations, as the motor support and discharge elbow are integral.

2. Variation of the length of the discharge column makes this type of pump installation very flexible.

3. No priming is required because the pumping element is generally submerged.

4. The pump head and the motor can be located above the high-water level to avoid flooding and motor burnouts.

5. Simplicity of design accompanied by rugged construction eliminates one stuffing box and reduces maintenance.

When considering short-coupled, vertical-shaft turbine pumps, it is well to bear in mind some of the conditions that govern the physical proportions.

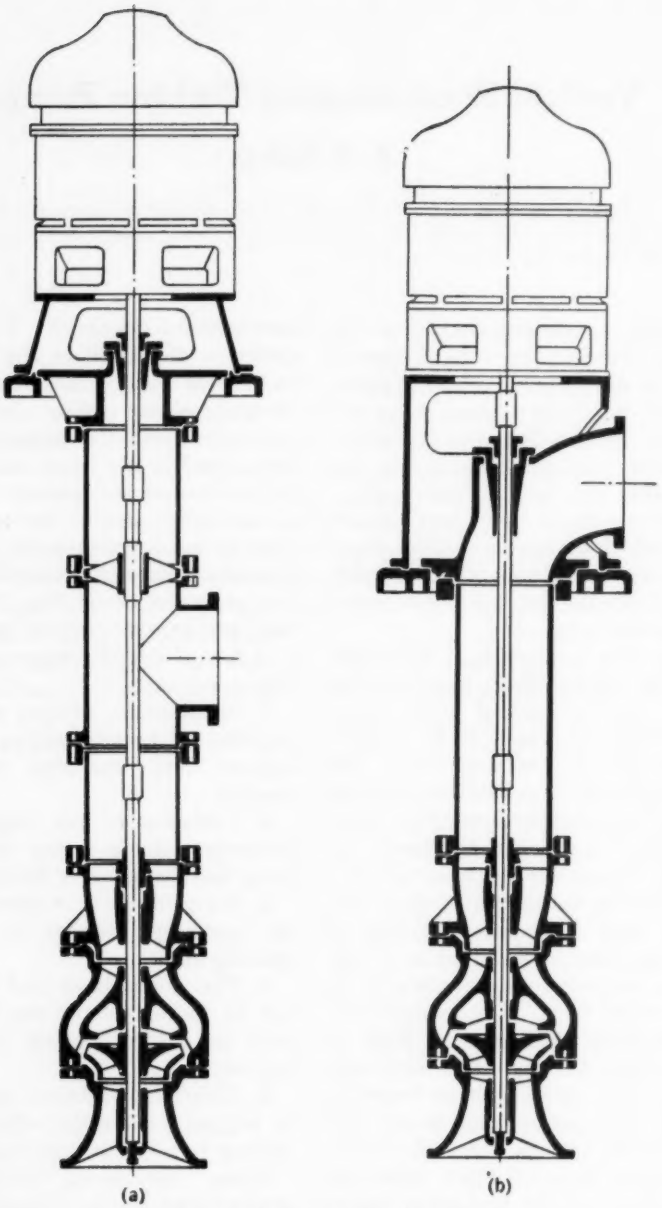


Fig. 1. Typical Short-coupled Pumps

Key: (a) underground discharge; (b) aboveground discharge.

In general, the pump diameters are held to relatively small values, producing a higher water velocity for a given head than that common in horizontal pumps. A certain amount of absolute pressure is required at the impeller entrance of any centrifugal pump. Because of higher velocities, this pressure should be slightly greater for vertical, concentric-case pumps. This increase can be obtained by augmenting atmospheric pressure with impeller submergence.

Major troubles in centrifugal-pump operation are due to suction and thrust conditions. Vertical centrifugal pumps with an open suction, taking the fluid from a free pool with exposed atmospheric surface, are more susceptible to trouble from insufficient submergence and unequal velocity distribution at the impeller eye. In horizontal pumps, the length of the suction pipe places the impeller at a distance from the fluid supply, thus tending to "iron out" eddies created at the suction entrance and to eliminate any effect of prerotation at the impeller eye which might cause secondary currents in the suction pool. The short-coupled vertical pump, when fitted with an open suction and taking water from a free pool, may, because of the absence of a suction pipe, create secondary currents conducive to the formation of whirlpools moving about the pump suction.

Submergence Determination

When turbine pumps are installed in wells, whirlpools do not form, because the well casing is in close proximity to the pump body. The question of proper impeller submergence remains, however, regardless of whether the pump is installed in a well or a sump. Studies on suction conditions have resulted in an empirical factor, Σ, which is used to determine how much negative lift a pump will sustain or how much positive head must be imposed. All centrifugal-pump bodies must, however, be filled with water at the start of operation. Under certain capacity and head conditions, pumps will operate with a lift below the impeller, so that short-coupled pumps must be provided with suction pipes.

Very few data are available on the Σ factor, but some have been published with the qualifying statement that they should be used with caution whenever high specific speeds are encountered. Any data on the subject, regardless of origin, will be tentative. Several values of Σ can be selected for a given specific speed. High values apply to so-called stock pumps and low values to special pumps of careful design and manufacture. Σ values are cavitational indexes and are primarily dependent upon impeller design. Two pumps of different manufacture, but for the same duty and identical specific speed, may have different values of Σ.

Although the determination of critical Σ requires very precise testing, routine tests on pumps have provided a limited amount of data consistent enough to permit extrapolation. Based on this information, Fig. 2 shows general values of Σ for various specific speeds. (Specific speed (N_s) expresses a relationship between pump capacity (Q, in gpm), head per stage (H, in ft) and speed of rotation (S, in rpm); it can be calculated from the formula: $N_s = Q^{\frac{1}{2}} \times S \div H^{\frac{3}{4}}$.)

Daugherty (*1*) utilizes the following equation for determining the level of water either above or below the impeller:

$$L_{max} = b - P_v - h_f - \Sigma h$$

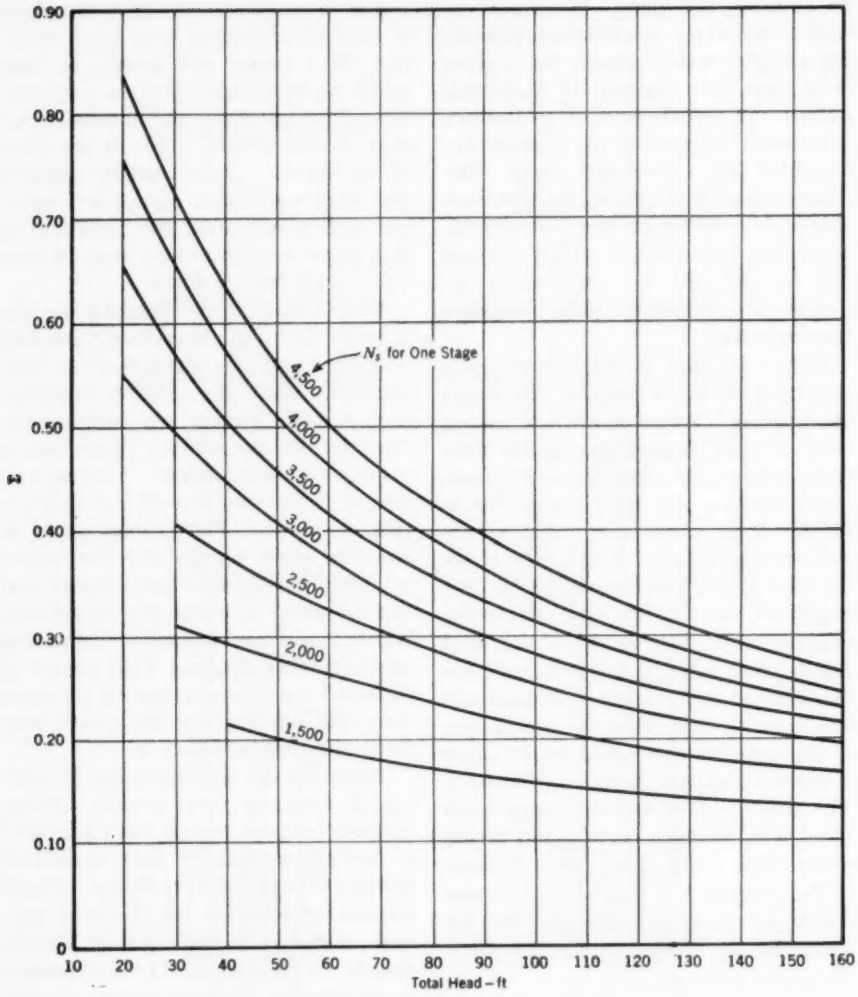
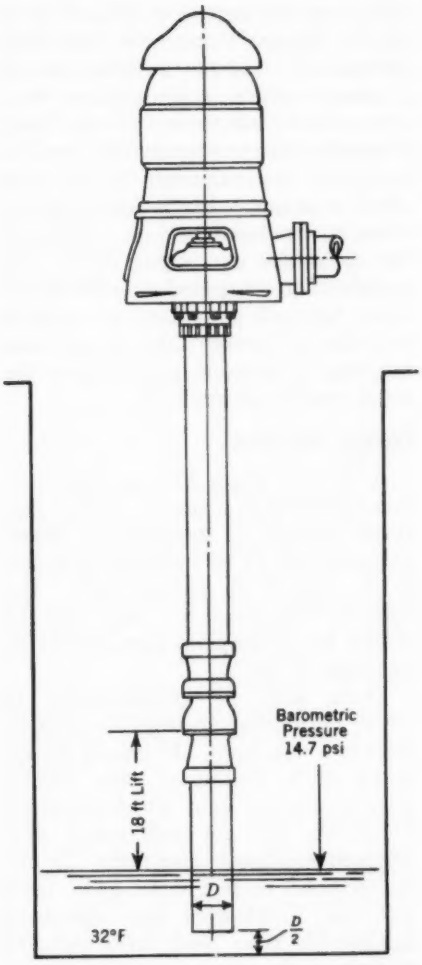


Fig. 2. Values of Σ

The chart shows general values of Σ for various specific speeds and total heads (for one stage at maximum efficiency).

in which L_{max} is the maximum suction lift; b, the barometric pressure; P_v, the vapor pressure of the liquid in question; h_f, the friction loss in the suction piping; and h, the total head developed by the pump at the point of maximum efficiency. All values are expressed in feet of the liquid in question. If L_{max} as computed is positive, the fluid can be lifted to that height from a level below the pump, but if the value is negative, as it may be with



Physical data: capacity, 500 gpm; total dynamic head, 120 ft; rotation speed, 1,750 rpm; three-stage complete pump (head (h) *for one stage, 40 ft); specific speed* (N_s), *2,460;* Σ *value (from Fig. 2), 0.375; fluid temperature, 32°F; specific gravity (sp gr), 1.0; vapor pressure* (P_v), *0 psia (approximate); barometric pressure* (b), *14.7 psia; friction loss in suction piping* (h_f), *1 ft. Calculations:*

$$L_{max} = \frac{2.31b}{(sp\ gr)} - \frac{2.31P_v}{(sp\ gr)} - h_f - \Sigma h$$

$$= \frac{2.31 \times 14.7}{1} - \frac{2.31 \times 0}{1} - 1 - 0.375 \times 40$$

$$= 34 - 0 - 1 - 15$$

$$= 18\ ft$$

If L_{max} *as computed has a positive value, the fluid can be lifted to that height from a level below the median diameter of the blades at the eye of the impeller. If* L_{max} *is negative, the fluid must flow to the impeller by gravity. Net positive suction head* (NPSH) *may be calculated thus:*

$$NPSH = \frac{2.31(b - P_v)}{(sp\ gr)} - L_{max} - h_f$$

$$= \frac{2.31(14.7 - 0)}{1} - 18 - 1$$

$$= 15\ ft$$

Fig. 3. Submergence Calculations

large values of Σ, the liquid must flow to the pump by gravity.

For a fluid with a specific gravity other than unity, an equation of the following form can be used:

$$L_{max} = \frac{2.31b}{(\text{sp gr})} - \frac{2.31P_v}{(\text{sp gr})} - h_f - \Sigma h$$

in which L_{max} is the maximum lift (ft); b, the barometric pressure (psia); P_v, the vapor pressure (psia); h_f, the friction loss in the suction piping (ft); h, the total head (ft) developed by the pump at the point of maximum efficiency; and sp gr, the specific gravity of the fluid.

A typical example of submergence calculations using the information men-

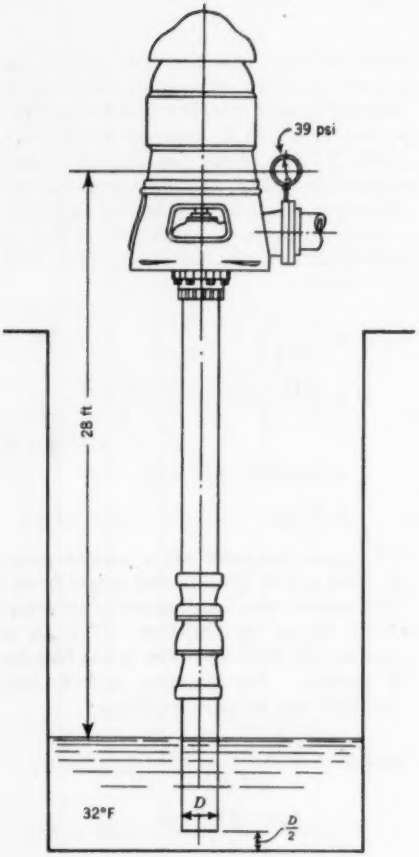


Fig. 4. Total-Head Calculations

The applicable physical data in this example are the same as in Fig. 3. To obtain total head, in feet: multiply gage reading, in psi, by 2.31 and divide by specific gravity of fluid; then add column loss, distance to water, and suction pipe loss. In the example shown:

Total dynamic head

$$= \frac{39 \times 2.31}{1.0} + 1.0 + 28.0 + 1.0$$

$$= 120.0 \text{ ft}$$

tioned in this article is presented in Fig. 3. Figure 4 illustrates total head calculations. As the Σ values are of a general nature, it is suggested that, when calculations show a positive head is required at the suction, this head be increased approximately 1 ft; and when a negative lift is indicated, its value be decreased by 1 ft. Although the Σ values are conservative, the modifications suggested are intended to allow for such conditions as aeration in order to prevent the pump from reaching a breakoff point before the rated capacity is realized.

Design Features

A vertical pump with an open suction operating in a suction well or reservoir exposed to atmosphere is sensitive not only to submergence but also to the size of the suction well. The author's experience has suggested the design for multipump installations illustrated in Fig. 5.

There may be circumstances in which the pump submergence must be held to a minimum. If several pumps under such conditions take suction from a common sump which is not divided into cells for each pump, pronounced whirlpools may form. In one installation, three 10,000-gpm units and one 15,000-gpm unit, operating against 150 ft of head, were installed to take suction from one large reservoir. Without dividing walls between the pumps and with minimum submergence, whirlpools were generated about the large unit at the wall 20 ft from the pump. None appeared to originate at the near wall, 12 ft away. The whirlpools slowly found their way to the pump column and dissipated. As they hovered around the column, a funnel was observed which extended

down to the suction entrance. The pump suctions were later fitted with a "vortex breaker" made of ¾-in. steel, approximately 36 in. in diameter and 15 ft deep, with six radial ribs running in close to the center. This stopped all whirlpool formation.

Another installation consisted of five 11,000-gpm pumps, in a 30-ft diameter caisson, fed by a siphon from the Mississippi River. During 9 years of operation no whirlpools were observed at the water surface, but the lowest impellers were submerged 34 ft. If any whirlpools existed underwater, they did not affect pump performance. To date no data are available on the amount of submergence required to eliminate the appearance of surface whirlpools.

When determining the depth of setting, it is important to know the minimum distance from the bottom of a reservoir to an open pump suction. Tests were conducted in 1940 to determine this value. No effect on performance was noticed until the distance from an 8-in. suction to a flat plate was less than 1½ in. During the test, the capacity was held constant and readings were taken for seven different locations of the plate. As there may be variations in suction pipe diameters for a given capacity, it is suggested that the distance from the suction to the reservoir bottom be equal to one-half the diameter of the suction. There is no advantage in having a great clearance, and there may be a disadvantage because a large space may favor the formation of eddies.

Occasionally a vertical pump is installed in a dry well and the suction line extended to and through the wall of a reservoir. A 90-deg elbow fitted in the line and connected to the pump suction does not detract from the excellent performance of a short-coupled vertical pump. A few years ago a question was raised about the effect on the performance of a vertical-turbine pump when the suction was fed by a pipe system in which two 90-deg elbows were close coupled and connected directly into the suction nozzle. In effect, a U-tube is produced, one leg being the vertical suction riser, the other the vertical pump, with the bottom of the U the two 90-deg elbows. A test conducted on such a suction system revealed that the loss was equal to the friction in the two elbows. From this it was concluded that the ribs in the suction nozzle served to straighten out any parasitical movements of the water due to the flow reversal caused by the elbows.

The discharge column of a pump is, in general, not very long, but, when a pump is shut down, this pipe will be empty to the water level in the suction well. Frequently an air release valve is provided at the pump discharge, with a waste pipe directed into the suction well. If the waste pipe terminates near the pump column and if the valve is set to discharge some water before it closes, the spent water may agitate the suction reservoir and cause air to enter the pump suction. When air release valves of appreciable size are required, the waste pipes should be a considerable distance from the pump columns.

Foundation bolts should always be used on short-coupled pumps. They are not essential when deep settings are involved, as the weight of the column and pump is sufficient to hold the unit in place and alignment. With short-coupled units, the reaction due to a slow-opening check valve may create

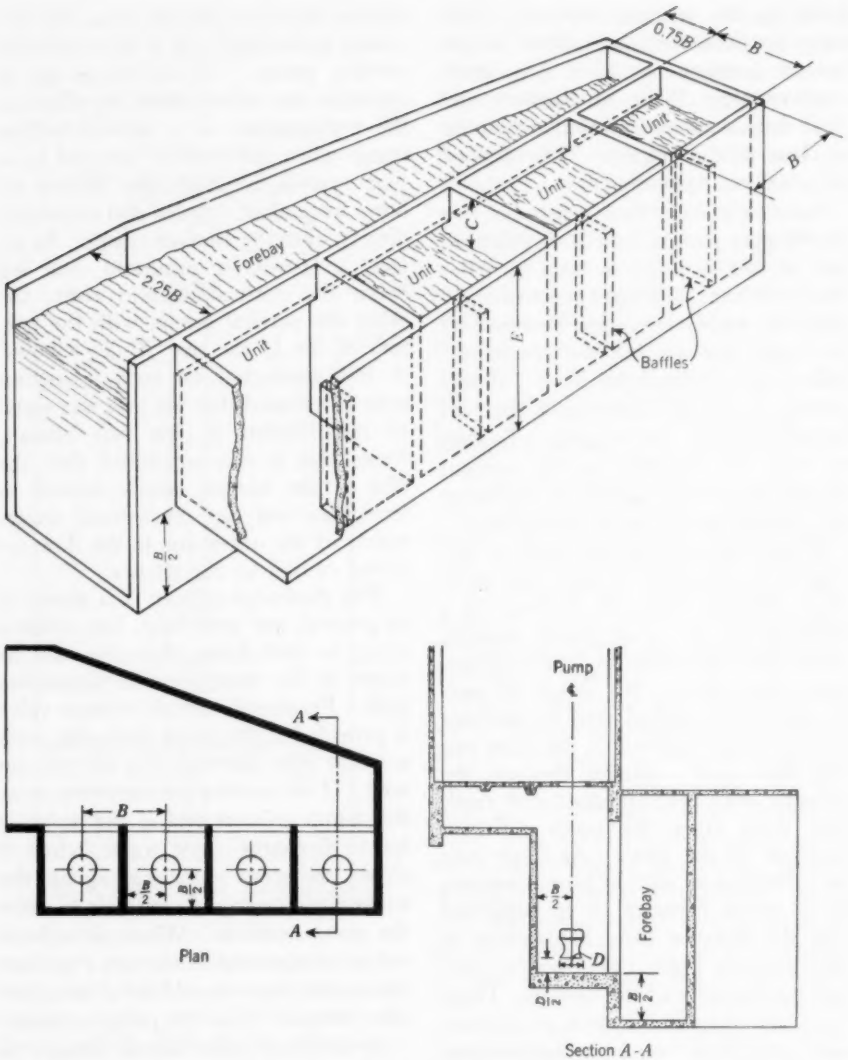


Fig. 5. Suggested Suction Bay Design

Single- or multiunit construction can be employed. A four-unit type is illustrated. Pumps are located in center of cubicles. The "stepdown" design (½D) assists in the subsidence of potential sedimentation. For normal pump performance, the distance from the suction bell to the pit floor should be one-half the suction bell diameter (D). *Any setting greater than* ½D *will not be beneficial to pump performance. Values of* B *and* D *for various capacities are given in Table 1. The factory should be consulted for specific recommendations, as proper submergence is of prime importance.*

a force tending to move the pump out of position. Some form of support should be secured to the pump column to absorb the lever action set up by the check valve. In one installation, the motor reached full speed before the 24-in. automatic check valve was completely open. The reaction was sufficient to rip the foundation bolts and 10-in. channel irons so that the pump head with a 700-hp motor tilted at a precarious angle. This condition was remedied by adjusting the valve and providing means to tie the pump column to an adjacent wall.

A floor design with a good safety factor is recommended. Otherwise, vibration may set up structural weakness.

Thrust Problems

Short-coupled vertical-turbine pumps present special thrust problems. Generally, hollow-shaft motors are used. The pump shaft extends up through the motor shaft, the top end being keyed to a driving hub at the upper end of the assembly. An adjusting nut on the pump drive shaft controls the vertical position of the pump impellers.

The upper housing of the motor contains the thrust bearing which carries both the hydraulic thrust and the weight of the shaft and impellers. Single-suction impellers are generally employed. In actual service, the hydraulic downthrust will vary when the output, or head, on the pump changes. This always happens when the water level changes on the suction side or the discharge pressure is regulated.

As an example, consider a pump rated at 1,000 gpm with a 100-ft head. If the 100 ft is the elevation above ground level into a reservoir, the pump would be located practically at ground level. This would be a short-coupled unit taking water from a surface suction bay. If the 100 ft is the depth to the water level in a well, the pump would require 100 ft of column. This would be a deep well pump discharging at ground level. Because both units deliver the same amount of water against the same head, the pumping elements would be identical. The short-coupled unit would be fitted with a short drive shaft, whereas the deep-set pump would require a long shaft of appreciable weight. In the deep setting, the dead weight of the shaft constitutes a fairly large percentage of the

TABLE 1

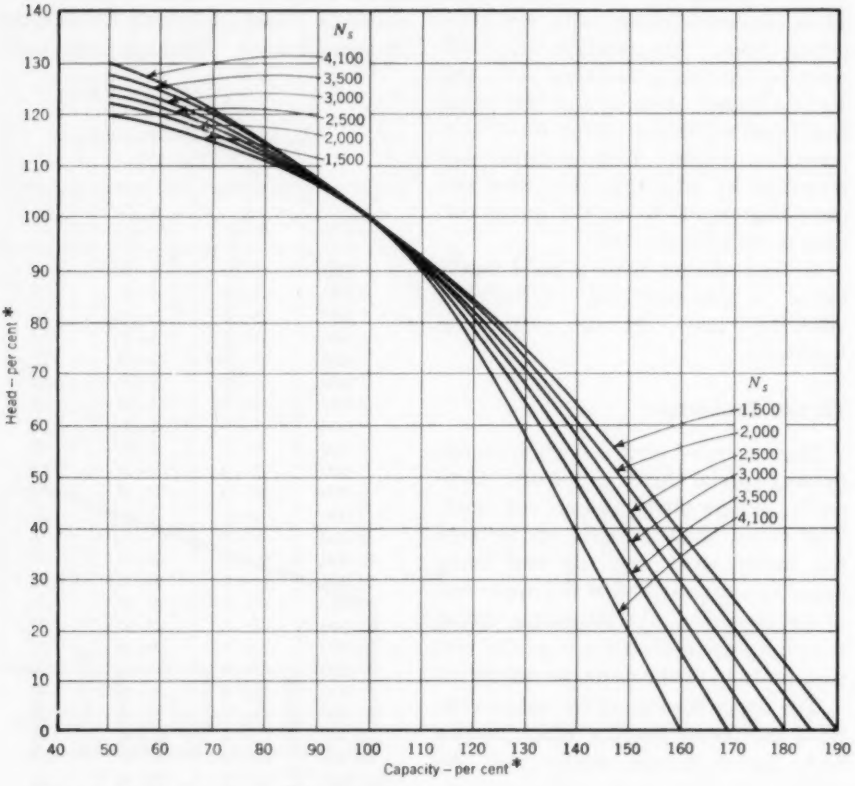
Suction Bay Design Data
(See Fig. 5)

Capacity *gpm*	*B* *ft–in.*	B_{min} *ft–in.*	*D** *in.*
500	3– 0	3– 0	6
1,000	3– 4	3– 4	8
1,200	3– 4	3– 4	10
1,400	3– 6	3– 6	12
1,600	3– 8	3– 8	12
1,800	3–10	3–10	14
2,000	4– 0	4– 0	14
3,000	5– 0	5– 0	16
4,000	6– 0	6– 0	16
5,000	7– 0	7– 0	18
6,000	8– 0	7– 6	20
7,000	9– 0	7– 6	22
8,000	9– 8	7– 6	24
10,000	10– 6	8– 0	27
12,000	11– 6	8– 0	30
14,000	12– 0	8– 0	32
16,000	12– 8	8– 0	33
18,000	13– 3	8– 6	35
20,000	13– 6	9– 0	36
22,000	13– 8	9– 0	37
25,000	14– 0	9– 0	38
50,000	16– 6	12– 6	52
75,000	20– 0	16– 0	63
100,000	24– 0	20– 0	73

* Approximate.

total thrust load. Therefore, the thrust load will be greater in the deep setting.

The capacity or rate of flow of a centrifugal pump is associated with the head or pressure. In general, with similar impeller designs, will, according to the laws of homologous design, have head-capacity curves of the same slope. In Fig. 6, the abscissas represent percentages of capacity at



* Capacity (head) at maximum efficiency equals 100.

Fig. 6. Head-Capacity Curves

Head-capacity curves of turbine type centrifugal pumps are shown at various specific speeds (N_s).

when the head is decreased, the capacity is increased. When the head is increased, the capacity will decrease. The degree of change determines the slope of the head-capacity curve. Pumps of the same specific speeds, maximum efficiency, and the ordinates represent percentages of head at maximum efficiency.

The downthrust, like the head, is also associated with capacity, because the downthrust is created by the head

generated by an impeller. Therefore, the relationship is such that, when the head on a pump is decreased, the downthrust is decreased and the capacity increases. If the head is increased, the thrust, naturally, is increased and the capacity is decreased. Assume all resistance is removed from the pump discharge and the head is zero. Neglecting the weight of the shaft and impellers and the momentum of the axial flow of entering water, this condition can be considered imaginary. The thrust will be zero. If the effective head does become zero, the machine is no longer a pump as the function of a pump is to overcome head or deliver water from one level to another.

If, in starting a short-coupled pump, the discharge head is appreciably lower than the normal head, the flow into the eye of the impeller will be great because of overcapacity. This causes a lifting force beyond that of the combined downthrust and dead weight. The lifting force may be only momentary or it may continue for a limited time.

Forces Involved

There are four forces that control thrust characteristics: [1] the force created by the impeller, which exerts a pressure in the casing; [2] the dead weight of the impellers and the drive shaft; [3] the centrifugal force in the waste water space between the rotating impeller and the casing, this action forming a rotating paraboloid; and [4] the force due to the momentum of the axial flow of the entering water as it impinges upon the cone-shaped impeller hub at entrance, the flow being changed from axial to radial. The fourth force is the principal one causing the upthrust in short-coupled pumps.

If the exact calculation of the four forces acting in unison could yield a mathematical resultant, limits of thrust bearing capacities could be established to anticipate thrust values both down and up. The known scientific facts governing hydraulics can be combined with experimental data to arrive at some practical and profitable rules concerning the desirable form of thrust bearings for vertical hollow-shaft motors driving short-coupled pumps.

Consider the first of the four forces which control thrust characteristics. With a single-suction impeller in operation, pressures will exist in the open spaces between the impeller sides and the surrounding case. These pressures, exerted upon the unequal areas of the rotating impeller shrouds, produce an axial thrust in a direction opposite that of inflow at the impeller eye. In a conventional vertical-turbine type pump, this is downthrust (Fig. 7a). If the physical proportions of the impeller, the pressure per stage at various capacities, and the number of stages are known, the theoretical downthrust can be calculated.

The second factor—the weight of impellers and drive shafts—needs no elaboration. The third force, created by the rotating paraboloid (Fig. 7b) in the two waste water spaces, is not great. Roughly, the factors affecting the paraboloid are the surface quality of both the moving impeller shrouds and the stationary walls of the pump case, the depth of the spaces, and the shape of the waste water cavities. Risking criticism, the author chooses to ignore this force.

The fourth force, created by the axial momentum of the water entering

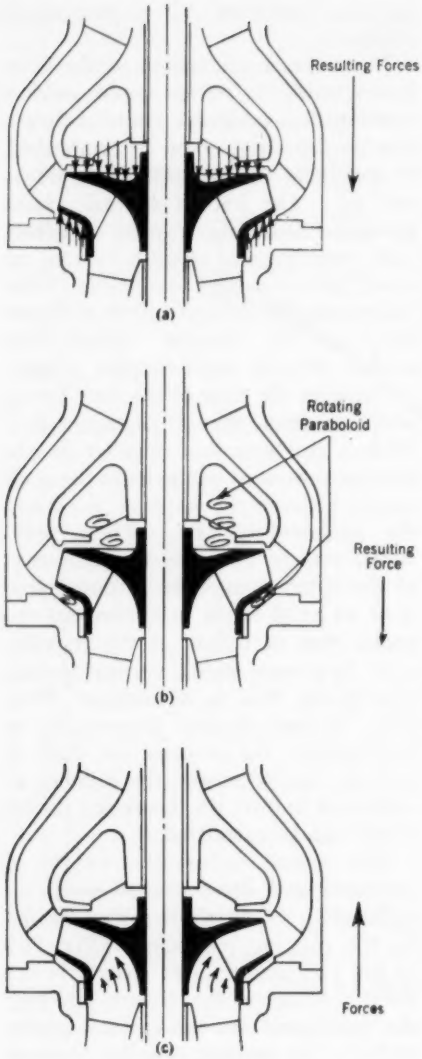
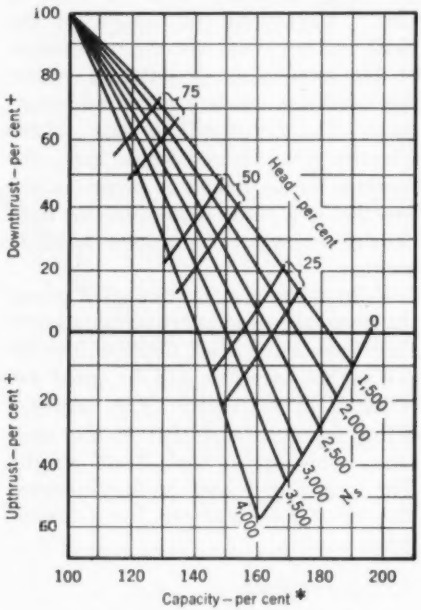


Fig. 7. Thrust Forces

Forces controlling thrust characteristics are shown.

the impeller, is opposed to the major downthrust forces (Fig. 7c). In short-coupled pumps, this force is the main reason for the so-called special thrust problems. It is a resultant of several factors and is similar to the paraboloid force but, unfortunately, cannot be considered as casually.

Factors affecting the fourth force are the area of the impeller inlet and the net positive head forcing the water



* Capacity at maximum efficiency equals 100.
† Downthrust at maximum efficiency equals 100.

Fig. 8. Hydraulic-Thrust Chart

Hydraulic-thrust percentages are shown for turbine type centrifugal pumps at various specific speeds and total heads.

into the impeller. If the net head is dependent upon atmospheric pressure alone, the inlet velocity will be limited and a condition can be attained such that there will be no increase in capacity regardless of a speed increase. This results in the familiar head-capacity curve that suddenly departs

from the smooth, descending slope and precipitates into a straight, vertical drop.

The location of the vane ends at the impeller entrance is another factor. If they extend into the opening appreciably, the axial flow of the entering water is gradually guided and directed radially. In this manner, the momentum of the water will not be as effective in creating the fourth force. Thus, this force is the result of complex factors that can be varied at will. They are subject to infinite variations in design. Only the first two forces can be computed accurately, calculations of forces three and four being highly speculative.

If a pump works in the field at a lower head than was anticipated, and the impeller submergence is insufficient, the pump will operate in the drooping portion of the head curve. The penalty will be cavitation, and the unstable forces at work will cause rapid and violent variations in thrust values.

Predetermination of Thrust Characteristics

A means of predetermining the thrust characteristics of a short-coupled pump would supply practical data for use in selecting thrust bearings. The author proposes a chart (Fig. 8) based on the following premises: that the specific speed of a pump affects the thrust values; that there will be a "net positive suction head" (NPSH) sufficient for a liberal overcapacity in pump discharge; and that there will be no balance ring on the impeller. The chart requires further qualifications. The thrust curves are projected to zero head. Very little information was available on this phase, but there was an abundant amount of thrust data on positive total heads. Fortunately, the few readings on thrust at zero head complemented the positive-head values. The chart does not imply that pumps in operation work at zero head but rather illustrates graphically the complete thrust characteristics.

Centrifugal-pump characteristics proposed by manufacturers rarely show an overcapacity of 50 per cent. The overcapacity decreases as the head per stage at the rated capacity increases. Because of complexities, it would be well if consulting engineers did not specify overcapacities necessitating very special pumps, although there may be rare occasions when great overcapacities are required. A typical example is found in the Underwriters Fire Pump Code, which arbitrarily stipulates 50 per cent overcapacity and also puts limits on the total head at this discharge. A pump built to meet the code can hardly be considered a typical centrifugal pump insofar as head curve characteristics are concerned. The degree of overcapacity of any centrifugal pump is principally determined by the specific speed with respect to the total head of one impeller. For several different makes of pumps, all of the same specific speed, different overcapacities will obtain. The actual design of the impeller and other component parts accounts for this difference. Generally, the overcapacity value is accompanied by the drooping head curve. If, in operation, the head on a pump is progressively lowered and there is relatively no increase in capacity, cavitation will occur.

Inspection of Fig. 8 shows that, if the overcapacity never exceeds 50 per cent, there will be no hydraulic upthrust at a specific-speed design of 3,400 or less when the total heads are

more than 30 per cent of the normal head. Fortunately, almost all short-coupled applications operate at specific speeds under 3,500. Of course, this applies to pumps running at full speed and with an operating head which will never be less than 30 per cent of normal at any time. From an engineering point of view, it would be poor economy to sell a pump with an operating range extending down to 30 per cent head, although there might be instances involving ruptured discharge pipelines where the overcapacity would reach 50 per cent and the head recede to 30 per cent normal.

Design Considerations

The author is convinced that a properly engineered pump installation will minimize upthrust troubles. On starting, there will be a momentary force tending to create upthrust, and there might well be a very short interval of upthrust; however, as the motor attains full speed and the discharge head builds up, the impellers and shaft will create downthrust. The duration of upthrust will depend largely upon the time interval required to accelerate the motor to full speed.

A good example is provided by a 15,000-gpm unit working against 150 ft at 1,180 rpm. Driven by an 800-hp induction motor, the unit attains full speed in 2½–3 sec. The setting is only approximately 12 ft deep, and at no time during starting or operation could any upthrust be detected. This pump has been operating constantly with daily starts and stops for 2 years.

If no upthrust bearing is incorporated in the motor, a heavy-set screw collar can be attached to the head shaft just below the motor. This thrust collar prevents the pump shaft from rising and causing damage to the thrust bearing in the motor, which is generally arranged for downthrust only. The electric-motor manufacturers can lock a bearing in the assembly to take the momentary upthrust when starting. The bearing should not be required to take continued upthrust.

The type of thrust bearing used in high-thrust applications is very important. Unconfirmed reports state that spherical roller thrust bearings installed in vertical motors have produced upthrust under test. The tests were made on a motor running at full speed and not connected to any load. If these test results are accepted, spring loading should be employed; otherwise, the pump alone will be suspected of creating all upthrust.

Short-coupled pumps should be classified apart from deep well pumps. The motor and pump shafts should be tied together to take care of all anticipated thrust variations. As the motor and pump are directly connected, they must be in alignment. The hollow-shaft motor must be concentric with the pump shaft, and this is most readily assured by utilizing a rabbet fitting between the motor base and the pump discharge casting. Stuffing boxes give better service when the shaft runs concentrically, and it is essential that the shaft be concentric when using mechanical seals.

In a short-coupled vertical unit, the nonreverse ratchet in the motor can be eliminated. It is not required in horizontal pump installations. It does serve a purpose in deep settings where the receding water in a pump column tends to cause reverse rotation. With the pump and motor shaft coupled and locked together and the motor equipped with a bearing capable of

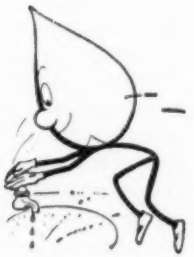
handling an upthrust equal to 30 per cent of the downthrust, the self-release pins at the drive coupling should be eliminated, as they serve no purpose.

Recently tests were conducted on two single-stage model pumps whose characteristics and dimensions were the basis for the design of prototype pumps. The models, of different sizes, were installed in the test laboratory with settings not over 6 ft deep. No allowance was made for column or shaft loss. The bronze impellers were well finished, and the cast-iron pump bodies were not enameled or treated with any kind of coating. Capacities were measured by venturi throats and checked by Francis weir measurements. Total heads were measured by a mercury column and power by a dynamometer checked with a calibrated wattmeter. One pump, of $10\frac{3}{8}$-in. OD, when operating at 1,765 rpm, delivered 800 gpm against $37\frac{1}{2}$ ft and developed 85 per cent laboratory efficiency. The other unit (20-in. OD), operating at 1,190 rpm, delivered 4,300 gpm against 50 ft of head and developed 90 per cent laboratory efficiency.

Pumps of such efficiency are possible when design proportions are not restricted. It is not necessary to skimp on bearing proportions or employ microscopic wearing ring clearance. Sound mechanical and hydraulic designs, coupled with excellent manufacturing standards, make possible more efficient pumps.

Reference

1. O'Rourke, C. E. *General Engineering Handbook*. McGraw Hill Book Co., New York (2nd ed., 1940). p. 810.



Recommended Procedures in the Use of Chlorine at Water and Sewage Plants

Joint Committee Report

A report submitted in August 1953 by the Joint Committee on Chlorine Supply.

Committee Personnel

Members	*Organization Represented*
WARREN J. SCOTT, *Chairman*	Conference of State Sanitary Engrs.
RAYMOND J. FAUST, *Secretary*	American Water Works Assn.
L. H. ENSLOW	Federation of Sewage and Industrial Wastes Assns.
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Introduction

AS an introduction to this report it may be of interest to explain *why* and *when* the Joint Committee on Chlorine Supply was established. The answer to "why" the committee was formed may be found in the abnormal business relations experienced between user and manufacturer of chlorine during the hectic days of World War II and the postwar era. During this period the chemical industry experienced a phenomenal growth. Demands for chemicals, including chlorine, were so great that service suffered, not as to quantity requirements but as to the type of container unit furnished. Many plants wanting ton containers could not get them. They were obliged to use smaller package units. It was to investigate this and other related problems that the Federation of Sewage and Industrial Wastes Assns., in October 1950, established a special committee on chlorine supply. The objective of this committee was to study problems of chlorine supply and distribution in the water and sewage fields, and to develop recommendations for their solution. At that time a similar committee existed in the Conference of State Sanitary Engrs. The U.S. Public Health Service and various state departments of health were also active in trying to correct the situation.

In May 1951 all independent activities on finding a solution to the chlorine supply problem were combined under the Joint Committee on Chlorine Supply. The members of the joint

committee represented the AWWA, the Conference of State Sanitary Engrs., the U.S. Public Health Service, and the Federation of Sewage and Industrial Wastes Assns.

In 1952 the board of directors of the Chlorine Institute, Inc., New York, set up the Public Health Advisory Committee, on which the following organizations were to be represented without vote: American Public Health Assn.; American Water Works Assn.; Conference of Municipal Public Health Engrs.; Conference of State Sanitary Engrs.; Federation of Sewage and Industrial Wastes Assns.; and U.S. Public Health Service. Fortunately members of the joint committee were authorized to represent their organizations on the Public Health Advisory Committee of the institute. Thus, a direct contact with the manufacturers was available and progress of the joint committee was facilitated, enabling completion of this report. Although certain sections of the report were discussed with manufacturer representatives, the responsibility for the report rests entirely with the joint committee.

The report has as one of its objectives the standardization of procedures in the use of chlorine in the sanitation field, such as the size of chlorine package to use; the inventory at users' plants; the return of chlorine containers, etc. To make such a program work requires its application by and cooperation between consulting engineers, public health engineers, executives and operators of water and sewage plants, and the chlorine manufacturers. The committee is hopeful that the recommendations set forth in the report will receive sufficient support to assure benefits to all concerned. Undoubtedly exceptions will be found to this procedural document but they should be few.

The report deals with 11 separate subjects, as follows:

1. Conditions of use for chlorine cylinders and ton containers
2. Chlorine inventories at water and sewage treatment plants
3. Transportation of liquid chlorine
4. Policy and practices in return of empty containers to chlorine suppliers
5. Safety in the use and handling of chlorine
6. Standby chlorination equipment
7. Stationary bulk storage of liquid chlorine
8. Procedure to be followed to secure chlorine in an emergency
9. Known manufacturers of chlorinators and equipment for feeding hypochlorites
10. Liquid-chlorine producers and repackagers in the United States, Canada, and Cuba
11. Producers of dry hypochlorites.

The information in items 9, 10, and 11 was furnished by the Chlorine Institute and is correct to the best of its knowledge.

As a matter of information, the capacity for the production of chlorine gas in the United States has increased rapidly. In 1950 production was 2,372,500 tons per year and in 1953 production estimates are 3,467,000 tons of chlorine gas. About 50 per cent of the gas production is liquefied for shipment. Liquid chlorine used for sanitation purposes in 1950 was 73,000 tons and in 1953 is estimated at 89,000 tons. These figures represent 6.2 and 5.2 per cent of the total production of liquid chlorine for the years 1950 and 1953, respectively. Thus, sanitation chlorine is a minor production item to the industry. Its application in the sanitary field, however, represents one of the most important uses for chlo-

rine—a use of chlorine which must be met irrespective of all exigencies.

It is of vital importance to the public health and welfare that the ever-increasing demands for chlorine in the treatment of water and sewage and in other uses for sanitation purposes be met by expanding production as needed and by necessary adjustments in the methods of distribution of the chemical.

Recommended Procedures

The American Water Works Assn., in publishing this report, considers that the information contained herein is drawn from reliable sources. The Association, as well as the members of the Joint Committee on Chlorine Supply, make no guarantee, jointly or severally, of results and assume no liability, jointly or severally, in connection with the information herein contained or the safety suggestions herein made. Moreover, it should not be assumed that every acceptable safety procedure is contained herein; or that abnormal or unusual circumstances may not warrant or require further or additional procedure. These suggestions should not be confused either with state, municipal, or insurance requirements or with national safety codes.

Conditions of Use for Cylinders and Ton Containers

It is considered that rates of chlorine gas withdrawal should not exceed 40 lb per 24 hr for a 100-lb or 150-lb cylinder or 450 lb per 24 hr for a ton container. It is recognized that, for short periods of time, these rates may be exceeded (by as much as 50 per cent for a period not exceeding 2 hr) and that, under some circumstances, with use of an evaporator, liquid chlorine can be drawn from a ton container to an evaporator at a rate much in excess of 450 lb per 24 hr. Recommended uses of cylinders or ton containers are shown in Table 1.

It is assumed that, for continuity of operation in most water or sewage works or industrial-wastes systems, spare cylinders and spare ton containers would be hooked up. This may mean a special manifold should be ordered to permit connecting up extra cylinders or ton containers.

Chlorine Inventories

In the final analysis, the chlorine inventory at a user's plant must be predicated solely on the single objective that the treatment must not be stopped because of a lack of chlorine. Public health protection requires continuity of chlorination for water and sewage treatment plants alike. It must also be recognized that there is no known suitable substitute or alternate method for accomplishing disinfection of public water supply and sewage plant effluents. Thus, an ample but practical inventory of chlorine at the user's plants is imperative. The question is: what is that amount?

The chlorine inventory needed at a water and sewage treatment plant can be determined by an analysis of the problem. The several factors that have a bearing on the problem are: [1] normal length of time required for delivery from shipping point to the user's plant; [2] the amount of chlorine used per day during periods of high requirements; and finally [3] emergencies which interrupt chlorine deliveries.

In an analysis of the above criteria, other factors immediately evolve—namely, the definitions of inventory terms. By defining terms an under-

TABLE 1

Recommended Uses of Chlorine Cylinders or Ton Containers

Total Consumption per 24 hr *lb*	Max. Rate of Withdrawal per 24 hr *lb*	Recommendation	Remarks
100	100	3 cylinders in use (possibly 6 connected)	
100	200	5 cylinders in use (possibly 8 connected)	
200	200	5 cylinders in use (possibly 8–10 connected)	ton containers may be justified*
200	300	ton containers†	1 carload would provide 150 days' storage*
300 or more	300 or more	ton containers†	1 carload would provide 100 days' storage at plants with minimum (300 lb per day) rate of use

* Delivered by truck; carload lot delivery not usually justified.
† Some changes in this schedule may be required for seasonal users of chlorine.

standing of the problem of chlorine inventory is greatly simplified. The terms that need definition are: [1] critical inventory; [2] working inventory; and [3] maximum inventory.

Critical inventory of chlorine at a water or sewage treatment plant is defined as the number of unconnected (full) chlorine units equal to the number of units normally connected and in service. Except for systems using less than 5 lb per day or for unusual circumstances, this type of inventory should not be considered. A plant should be considered in emergency operation with this limited inventory.

Working inventory of chlorine at a user's plant may be defined as that inventory which represents a reasonably ample supply to assure continuity of the disinfection treatment. In practice, it should approximate: [1] a duplication of the connected chlorine units (critical inventory); plus [2] a chlorine reserve equivalent to the length of time required for delivery from the shipping point to the user's plant (varies from 2 to 15 days' supply of chlorine, depending on local transportation conditions); plus [3] a chlorine reserve for exigencies (strikes, transportation interruptions, etc.) equivalent to a 15-day supply. The working inventory for any plant must be developed specifically for that plant and be based on actual conditions.

Maximum inventory is defined as that inventory which is equivalent to a 60-day supply of chlorine at the user's plant at normal rates of use. The small users of chlorine (5 lb per day or less) must be excepted from this definition. Beyond the small plant, there are few, if any, practical reasons to exceed the 60-day inventory. To do so ties up an unwarranted stock of cylinders and containers. Maximum inventories should be considered as being temporary only.

Regular chlorine shipping schedules or the placing of orders for chlorine should be developed or timed to main-

TABLE 2

*Recommended Chlorine Inventories at Water and Sewage Plants**

Avg Amount Chlorine Used per Day *lb*	Critical Chlorine Inventory None of Which Is in Use†	Working Chlorine Inventory None of Which Is in Use	Max. Chlorine Inventory None of Which Is in Use
	150-lb Cylinders		
0.5	1	1	2
2.0	1	1	2
5.0	1	1	3
10.0	1	3	4‖
20.0	1	4–5§	8‖
50.0	2–3	8–12§	20‖
100.0	3–5	16–24§	40‖
200.0	6–8	30–47§	80‖
	Ton Containers		
300.0	1	4–6§	9‖#
500.0	2	8–10§	15‖#
1,000.0	2–4	12–18§	30‖
2,000.0‡	4–6	22–35§	60‖

* 100-lb cylinders are available. Where they are used instead of the 150-lb cylinders, the net weight of chlorine in inventory should substantially agree with that shown in the table.

† This column also represents the number of cylinders or containers usually in service. Local conditions could affect these figures materially. Irrespective of the number of units in service, the principle as expressed in the definition of critical inventory should still apply.

‡ Users of 1 ton or more of chlorine per day should consider the use of single-unit tank cars.

§ The smaller of the two numbers represents the working inventory where deliveries require 2 days. The larger figure represents the working inventory where deliveries take 15 days.

‖ These figures roughly represent 60 days of chlorine inventory.

Maximum inventories listed for these categories are for plants receiving chlorine delivery by truck. For plants receiving chlorine delivery by railroad car (fifteen 1-ton containers), the maximum inventories should be 19 and 23 ton containers, respectively, for plants using 300 and 500 lb per day.

tain the chlorine inventories at the user's plants at approximately the working inventory as defined above. In practice, this objective may be difficult to attain, due to the size of chlorine deliveries, particularly where shipments are represented by carload lots. Thus, working inventories will vary in size; however, the extremes of these variations should be restricted between the critical and the maximum inventories. To maintain such a reasonable and well-defined inventory should prove advantageous to user and manufacturer alike.

Based on the foregoing definitions, Table 2 reduces to practical terms the critical, working, and maximum chlorine inventories for plants using chlorine at the rates of 0.5–2,000 lb per day.

Transportation of Liquid Chlorine

Chlorine is shipped as a compressed, liquefied gas in cylinders, ton containers, and single-unit tank cars. These three styles of containers are designed and built to the regulations and specifications of the Interstate Commerce Commission under a penal statute (62 U.S. Stat. 738).

The sizes of these styles of containers are as follows:

1. *Cylinders.* Cylinder capacities range from 1 to 150 lb of chlorine, but the 150-lb size is most frequently used.

Cylinders (usually known officially as ICC–3A480) may be shipped by motor and rail carriers in any quantity, subject to weight limitations. A minimum truckload lot weighs 23,000 lb gross or 20,000 lb gross in certain parts of the country, depending on truck tariffs. A 23,000-lb truckload constitutes approximately 86 cylinders of 150 lb net each. A minimum carload lot of cylinders weighs 30,000 lb gross throughout the United States and constitutes approximately 110 cylinders of 150 lb net each. The cylinder shells vary somewhat in weight, so scales should be adjusted accordingly for each cylinder being used. The approximate tare weights of 100-lb cylinders are 73 lb (lightweight type) and 85 lb (heavyweight type); the approximate tare weights of 150-lb cylinders are 92 lb (lightweight type) and 125 lb (heavyweight type).

2. *Ton containers and TMU tank cars.* The ton container holding 1 ton of chlorine may be shipped in any quantity on motor trucks or semitrailers, subject to weight limitations, and the empty ton containers may likewise be returned. A special form of tank car known officially at TMU (tank multiple unit), and the tanks known officially either as 106A500 or 106A500X, holding on an underframe fifteen loaded or empty ton containers, may be shipped to a siding owned by the consignee or leased from the rail carrier by the consignee. This TMU tank car may, under certain regulations of the Interstate Commerce Commission, be shipped to a nearby rail carrier track, the ton containers, both loaded and empty, being handled by the consignee. Rail carrier transportation of loaded ton containers except on TMU tank cars is prohibited. In the rail carrier transportation of TMU loaded tank cars, the weight for tariff purposes is the weight of the chlorine only. In the rail carrier transportation of empty ton containers, the TMU underframe must have fifteen empty ton containers. As an alternative, empty ton containers may be returned in any number by rail carrier transportation or by motor carrier. Freight rates via motor carriers apply on the gross weight of the loaded ton containers, except where minimum-quantity rates are in effect, in which event that minimum must be shipped. Special equipment is required for handling ton containers, whether delivered by truck or by rail. Stationary or movable cranes or traveling overhead rail hoists are necessary, along with some type of lifting rig.

3. *Single-unit tank cars.* These tank cars are in three sizes, holding 16 tons, 30 tons, and 55 tons chlorine, respectively. All three sizes are in use in sanitation, the two smaller sizes being most in use. A single-unit tank car must be consigned to and unloaded on a private or leased rail siding. The unloading of single-unit tank cars requires skill and should never be undertaken by other than trained personnel.

4. *Tank barges.* Chlorine may, under regulations of the U.S. Coast Guard, be shipped in multitank barges. There are tank barges in use capable of transporting up to 600 tons of chlorine. The unloading of such barges requires special skill and should be undertaken only after training under the direction of chlorine producers who have barges.

Return of Empty Containers

Liquid-chlorine shipping containers (100- or 150-lb cylinders, 1-ton containers, and single-unit tank cars) represent sizable funds invested by the

manufacturers or suppliers of liquid chlorine. The interest on the total invested funds in 150-lb chlorine cylinders or ton containers, plus depreciation on containers and valves, must be included in the factory-door cost of producing and packaging liquid chlorine. Furthermore, when governmental restrictions on the uses of steel are in force it is difficult for chlorine producers and suppliers to procure additional containers.

It should be clear, taking into account the above circumstances, that the larger the stock of containers a chlorine producer is required to own and maintain, the greater the factory-door cost of the packaged chlorine. Any group of chlorine purchasers which creates the necessity of producers' maintaining a larger inventory of chlorine containers comprises the least attractive (profitable) class of purchasers of chlorine. More importantly, that group of chlorine purchasers which does not promptly return empty containers may well create a more consequential problem—namely, that of an insufficient number of containers on hand for the producer to fill orders completely in a single shipment. This creates confusion at both ends and adds to the producer's cost of supplying the chlorine user, through splitting of shipments, extra bookkeeping, billing, etc. At the purchaser's end, it likewise adds to costs of handling, record keeping, etc. At the same time, the chlorine user who neglects to return empty containers as promptly as is permissible is not showing consideration either for the supplier or for other chlorine customers who may suffer the consequences of recurring shortages of containers in the hands of the supplier.

During World War II the matter of empty containers in the hands of those responsible for operation of water and sewage plants became a problem of marked consequence. The pleas for more prompt return of empty containers, in smaller shipments than customarily practiced, bore fruit and relieved a growingly serious situation. It behooves all users of liquid chlorine to reinstate the practice of prompt return of empty cylinders at regular intervals, regardless of the number available for return. When considering the number of water and sewage plants using chlorine, and multiplying this number by even a minor average number of returned cylinders per plant each month, the boost in the rate of cylinder turnover will result in an impressive accomplishment.

Seasonal Users

In instances where chlorination is provided on a seasonal basis, such as sewage effluent chlorination during the bathing season or for the seasonal protection of shellfish areas, the tying up of chlorine containers may be particularly objectionable should the chlorination season end with a sizable number of full chlorine containers on hand. In this instance, the municipality has a dead investment in chlorine to be carried through the nonuse months. This is particularly undesirable where the chlorine is being supplied in 1-ton containers, fifteen to the car.

Chlorine users in the seasonal category can do much to improve the container turnover picture if they will look ahead a bit and place their final order of the season at a time, and in a quantity, that will reduce the number of carryover full containers to a minimum. Possibly, whatever remains at the close of the chlorination season can be transferred to the local water department or, if need be, sold to an adjoining community.

Where 1-ton containers are involved, the user may find it expedient to procure chlorine in ton containers for transportation by truck, to finish out the chlorination season, rather than order another fifteen-unit car and tie up a number of these expensive containers during the nonchlorinating months. Second best would be the purchase of a less-than-carload shipment of chlorine in 150-lb cylinders to finish out the season.

There may be other methods of providing a more rapid rate of chlorine container turnover in given situations than have been suggested herein. The whole point of this discussion is an attempt to prevail upon plant operators to practice the golden rule in the matter of keeping chlorine containers in mobile circulation for the benefit of all concerned.

Safety in Use and Handling

It is essential for persons responsible for the procedures followed in the handling and application of chlorine at any installation to have a relatively comprehensive knowledge of the characteristics and properties of chlorine. It is not possible to establish a general set of rules or procedures that will assure safe use and handling of chlorine in all situations which may be encountered. For some situations, adequate safety will necessitate sound judgment and decisions based on a knowledge of the properties and effects of chlorine and of the fundamental design characteristics of chlorine applicators and other appurtenances. It is believed that users should at least be familiar with the contents of the "Chlorine Manual" published by the Chlorine Institute, Inc.—or an equivalent booklet published by a chlorine producer—and have a copy of either or both readily available for reference at all times.

General Recommendations

1. Only reliable men whose training in the handling of chlorine is commensurate with their responsibilities should be permitted to handle chlorine.

2. Chlorine and chlorinator rooms should be provided with adequate ventilation. In large installations, subsurface installations, or buildings occupied by persons or containing equipment subject to chlorine attack, a separate and reasonably gastight room, equipped with mechanical ventilation which will change the air twice every minute, is considered essential and is required by some local and state regulations. Exhaust duct ports should be at floor level and ducts should terminate through a completely separate exhaust system to a location high enough to insure atmospheric dilution without endangering personnel or adversely affecting property in the area. Air inlets should be located across the room from exhaust ports, with the air of such temperature that it will not affect the chlorination equipment adversely. Shutoff valves should be provided near chlorinators if the connected chlorine containers are in a separate room or a considerable distance from the chlorinators. Switches for fans and lights should be outside the room, at the entrance. The vent hose for the chlorinator should discharge to the outside atmosphere, above grade.

3. A suitable number of gas masks, of types approved by the U.S. Bureau of Mines, should be provided, and persons employed in the handling of chlorine should be trained in the use and maintenance of the masks. Gas masks should be located outside the probable

area of contamination so that it will be possible to reach them in case of emergency. Where chlorine is used over wide areas, masks should be available in several locations.

4. To test for chlorine leaks, attach a cloth to one end of a stick, soak the cloth with ammonia water, and apply to the suspected area. A white cloud of ammonium chloride will result if there is any chlorine gas leakage.

5. As soon as there is any indication of the presence of chlorine in the air, steps should be taken to correct the condition. Chlorine leaks never get better. Chlorine leaks always get worse if they are not corrected promptly. Solvay Emergency Devices, Kits A, B, or C, should be available for stopping leaks in chlorine containers, and men should be trained in the use of such emergency equipment. Telephone the chlorine supplier or any chlorine producer if in need of help. Always wear a gas mask when correcting chlorine leaks. If a chlorine container is leaking in such a position that chlorine is escaping as liquid, the container should be turned so that chlorine gas escapes. The quantity of chlorine escaping from a gas leak is about one-fifteenth the amount that escapes from a liquid leak through the same size hole. At regular points of storage and use, emergency preparations should be made for disposing of chlorine from leaking cylinders or ton containers. Chlorine may be absorbed in caustic soda, soda ash, or hydrated lime solution. Caustic soda is recommended, as it absorbs chlorine most readily. The proportions of alkali and water preferred for this purpose are given in Table 3.

6. Containers should be stored at a moderate temperature. Flames or direct heat should never be applied to a container. Chlorine containers connected to apparatus should be protected from a temperature higher than that of the equipment. When a number of containers are connected to the same manifold, chlorine may go from the warmer containers to the colder ones, which could result in filling some above the safe limit. The heating of containers involves danger because the fusible plugs are designed to soften or melt at a temperature between 158° and 165°F. At temperatures above 180°F, dry chlorine attacks steel.

TABLE 3

Recommended Alkaline Solutions for Absorbing Chlorine

Chlorine Container Size	Caustic Soda		Soda Ash		Hydrated Lime*	
	Weight *lb* (100%)	Water *gal*	Weight *lb*	Water *gal*	Weight *lb*	Water *gal*
100 lb	125	40	300	100	125	125
150 lb	188	60	450	150	188	188
1 ton	2,500	800	6,000	2,000	2,500	2,500

* Hydrated lime solution must be continuously agitated with vigor while chlorine is to be absorbed.

7. Avoid dropping or bumping chlorine containers. Containers should be securely fastened to prevent tipping or rolling.

8. Valve protection hoods on cylinder and ton containers should always be kept in place except when such are

being emptied. Do not hoist cylinders by the hood.

9. Keep valves of cylinders and ton containers closed at all times when not in service.

10. Store full and empty cylinders and ton containers in different places to avoid confusion. It is good practice to tag empties.

11. Use cylinders and ton containers in the order in which they are received. Cylinders and ton containers in active use should be located on a scale, so that the operator may know at all times the amount of chlorine in the cylinder or ton container.

12. Use nothing but approved fittings for connecting chlorine containers. Never use pipe fittings on chlorine valves.

13. The following first-aid measures are recommended for persons exposed to chlorine:

a. Carry patient from gas area. Patient should preferably be kept in a warm room (about 70°F). Supply blankets if necessary. Keep patient warm and quiet. Rest is essential.

b. Place patient on back, with head and back elevated.

c. *Call a physician immediately.*

d. Splashes of liquid chlorine and chlorinated water destroy clothing and, if such clothing is next to the skin, will provide irritation and acid burns. In such cases, remove clothes and keep patient warm with blankets.

e. A carbon dioxide and oxygen mixture with not to exceed 7 per cent of carbon dioxide may be given. This mixture, ready prepared, and sold with the necessary apparatus, can be administered intermittently for periods of 2 min, followed by 2-min rest periods, over a total period not to exceed 30 min. Instructions of the purveyor of the gas apparatus should be carefully obeyed. If a carbon dioxide and oxygen mixture is not readily available, oxygen alone may be used.

f. Milk may be given in mild cases, as a relief from throat irritation.

g. If breathing has apparently ceased, start immediately the back pressure–arm lift method of resuscitation.

h. Provide first aid as may have been prescribed for emergencies by the company physician pending his arrival.

Standby Chlorination Equipment

The use of chlorination equipment in water, sewage, and related fields may be dictated for various reasons. These would include, among others, protection of the public health from transmission of pathogenic microorganisms, prevention of unpleasant odors, reduction of oxygen-consuming potential, reduction of gross bacterial populations, and chemical stabilization of certain products. The following recommendations concerning the provision of standby equipment relate only to that use of chlorination in which the protection of the public health is the reason for chlorination.

Standby equipment should be available in any installation where chlorination is practiced for the protection of public health and welfare. This applies not only to water treatment plants (at which chlorination would be used for the protection of public health) but also to those sewage and industrial-waste treatment installations where chlorination of the effluent is demanded. Chlorination as used in sewage treatment for the protection of the health of the public might be directed toward the protection of a public water supply, of shellfish culture areas, and of bathing beaches. Determination of the need for protection in any instance rests with the responsible public health authorities.

In the small plant—whether it be water supply, sewage disposal, or industrial-waste treatment—requiring only one chlorinator for normal operation, one additional chlorinator should be provided for emergency situations. The size of the emergency unit should equal in capacity that of the basically required unit. In installations requiring two, three, or more chlorinating units in operation, standby needs should be met by providing a duplicate of the largest unit of the group, to provide one unit more than is required for normal maximum demand. Consideration should be given in the original design to the desirability of using several small units, providing flexibility not available with one or two large units.

Several general comments are made with regard to standby equipment. Of equal importance to provision of standby equipment is the regular, frequent servicing of all chlorinating equipment. Any standby equipment should be kept in perfect running order at all times. Borrowing of parts from standby equipment should not be permitted. A definite schedule of chlorinator use should include frequent routine operation of any standby equipment. Reliance on emergency equipment maintained by state health departments should not be considered as serving in lieu of standby equipment located at the installation itself. Possible availability of equipment from manufacturers should not be considered as meeting standby equipment needs. Knowledge of types of equipment used in nearby plants might prove of limited service at times when it might be possible to borrow a part of a chlorinating unit to replace a damaged or broken part.

No specific recommendations regarding standby equipment are made with regard to swimming pools. Although chlorination of pool water is practiced for the protection of the public, it is appreciated that the operation of swimming pools may be interrupted, thus providing an alternative to standby equipment in cessation of operation until repairs are made or until new equipment can be obtained. Hand-operated chlorination may sometimes be temporarily permitted. Whether standby equipment is provided is a matter of economics, to be decided by the proprietor of the swimming facilities. Local or state health regulations and supervision should prevent the operation of swimming enterprises if adequate disinfecting facilities are not available for any reason at all.

Many chlorine feeders employed in the treatment of water supplies, sewage, or industrial wastes are dependent on power to operate pumps or provide auxiliary water or air pressure used in connection with the feeders. Where there is also need for power to produce the flow of water, sewage, or industrial wastes that are to be treated, the power for the chlorine feeder may be derived from the same source; an interruption of the flow is timed with the interruption of the chlorination. However, where the flow of the liquid to be treated is by gravity or where the source of power to produce the flow is from some other source than the source used to operate the chlorinator, failure of the electric power or other power used to operate a chlorinator may cause interruption of the chlorine disinfection of the flow. A common practice is to install hydraulic pumps along with electric power to operate chlorinators, with the hydraulic pumps cutting in when electric power is interrupted.

In the air-operated chlorinators, air is usually provided by small, electri-

cally operated compressors. Interruption of the flow of compressed air through power failure will shut down the chlorinators. To prevent such interruption of chlorination, an auxiliary source of compressed air is required. This may be provided by a gasoline engine–driven auxiliary compressor or by a reserve supply of cylinders of inert gas such as carbon dioxide. A minimum of two cylinders of carbon dioxide in service at the same time on each chlorinator is required to operate one chlorinator for a minimum of 10 hr. The use of high-pressure carbon dioxide presents an operational hazard. Such an installation should be made and operated only in accordance with the recommendations of the chlorinator manufacturer.

Stationary Bulk Storage

Stationary bulk storage of liquid chlorine is practical for large water and sewage plants under these conditions: [1] the storage tanks are of proper construction for chlorine service; [2] the storage tanks are mounted so that the contents may be weighed at any time; [3] the tanks are well and properly maintained; [4] the quantity stored therein does not exceed safe loading limits; and [5] the loading and unloading practices are safe.

Hazards. The potential hazards of such storage are substantially the same as those of the storage of liquid chlorine in tank cars on water and sewage plant premises, differing only in that: [1] unskilled maintenance of the storage tank may result in escape of chlorine; [2] overfilling of the tank may cause hydrostatic rupture of the tank and the complete discharge of its loading to the surrounding air; and [3] in the event of fire, it will not be possible to move the stationary tank to a safer location.

Tank construction. A specification for stationary bulk chlorine storage installation is being prepared by the Chlorine Institute, Inc. Reference should be made to the specification when it becomes available.

Emergency Procurement

The procedure to be followed to secure chlorine in case of an emergency will necessarily be dependent on the general type of emergency which occurs. For the purpose of suggesting a routine procedure to be followed, emergencies have been separated into two types or categories, and a procedure applicable to each is suggested.

1. *Inability to obtain needed normal chlorine requirements from suppliers.* The user should make a reasonable effort to obtain chlorine. Three or more suppliers should be contacted and requested to supply the requirements. In the event that there is advertisement for bids and no bids are received, an inquiry as to why they have not submitted a bid should be made of the supplier or suppliers that have been filling the more recent orders.

If the above efforts fail to obtain the necessary supply of chlorine, a request for assistance should be directed to the state department of health. The state department of health should, if necessary, communicate the needs to the surgeon general of the U.S. Public Health Service, Washington, D.C., with a request for assistance. Information accompanying this request should include:

a. Purpose for which chlorine is used.

b. Quantity used in the past year.

c. Estimated requirements during the next 12 months.

TABLE 4

List of Suppliers, June 1953

Liquid-Chlorine Producers in the United States, Canada, and Cuba

State	City	Producer	Containers Filled*
		United States	
Ala.	Huntsville	Chemical Corps (leased to National Distillers Products Co.)	S
	Muscle Shoals	Chemical Corps (to be leased)	S
	McIntosh	Mathieson Alabama Corp.	S
Ark.	Pine Bluff	Chemical Corps (leased to Diamond Alkali Co.)	S
Calif.	Pittsburg	Western Div., The Dow Chemical Co.	C, T, S
Colo.	Denver	Chemical Corps (leased to Shell Chemical Corp.)	T, S
Ill.	Monsanto	Monsanto Chemical Co.	C, T, S
Kan.	Wichita	Frontier Chemical Co.	C, T, S
Ky.	Louisville	Goodrich Chemical Co.	
La.	Baton Rouge	Ethyl Corporation	
	Baton Rouge	The Solvay Process Div., Allied-Chem. & Dye Corp.	C, T, S
	Lake Charles	Columbia-Southern Chem. Corp.	C, T, S
Md.	Edgewood	Chemical Corps (leased to Diamond Alkali Co.)	C, T, S
Mich.	Midland	The Dow Chemical Co.	
	Wyandotte	Penn. Salt Mfg. Co.	C, T, S
	Wyandotte	Wyandotte Chemical Corp.	S
Nev.	Las Vegas	Stauffer Chemical Co. of Nevada, Inc.	S
N.H.	Berlin	Brown Co.	C, T, S
N.J.	Deepwater Point	E. I. du Pont de Nemours & Co., Inc.	
N.Y.	Mechanicville	West Vir. Pulp & Paper Co.	S
	Niagara Falls	E. I. du Pont de Nemours & Co., Inc.	
	Niagara Falls	Hooker Electrochemical Co.	C, T, S
	Niagara Falls	Niagara Div., International Minerals & Chem. Corp.	S
	Niagara Falls	Mathieson Chemical Corp.	T, S
	Niagara Falls	Niagara Alkali Co.	C, T, S
	Niagara Falls	Stauffer Chemical Co.	S
	Syracuse	Solvay Process Div., Allied Chemical & Dye Corp.	C, T, S
Ohio	Ashtabula	National Distillers Products Co.	S
	Barberton	Columbia-Southern Chemical Co.	C, T, S
	Painesville	Diamond Alkali Co.	C, T, S
Ore.	Portland	Pennsylvania Salt Mfg. Co. of Wash.	C, T, S
R.I.	Providence	Fields Point Mfg. Corp.	C
Tenn.	Memphis	Velsicol Corp.	C, T, S
Tex.	Corpus Christi	Columbia-Southern Chemical Corp.	C, T, S
	Freeport-Velasco	The Dow Chemical Co.	S
	Houston	Diamond Alkali Co.	C, T, S
	Houston	Ethyl Corp.	S
Va.	Hopewell	Hercules Powder Co.	S
	Hopewell	The Solvay Process Div., Allied Chemical & Dye Corp.	C, T, S
	Saltville	Mathieson Chemical Corp.	S
Wash.	Tacoma	Hooker Electrochemical Co.	C, T, S
	Tacoma	Pennsylvania Salt Mfg. Co. of Washington	C, T, S
W.Va.	New Martinsville	Columbia-Southern Chemical Corp.	C, T, S
	South Charleston	Westvaco Chemical Div., Food Machinery & Chemical Corp.	T, S
Wis.	Kimberly	Kimberly-Clark Corp.	
		Canada	
Ont.	Cornwall	Canadian Industries, Ltd.	S
	Sarnia	Dow Chemical of Canada, Ltd.	C, T, S
	Windsor	Canadian Industries, Ltd.	C, T, S
Que.	Arvida	Aluminum Co. of Canada, Ltd.	S
	Beauharnois	Dominion Tar & Chemical Co., Ltd.	S
	Shawinigan Falls	Canadian Industries, Ltd.	S
		Cuba	
Santa Clara	Sagua la Grance	Electro-Quimica de Sagua	C

* C—Cylinders; T—Ton Containers; S—Single Unit Tank Cars.

TABLE 4—*List of Suppliers (contd.)*

Liquid-Chlorine Repackagers

State	City	Repackager	Containers Filled*
Ala.	Birmingham	Wittichen Chemical Co.	C
Calif.	Duarte	Tops Chemical Co.	C, T
	Los Angeles	Western Div., Dow Chemical Co.	C, T
	Torrance	John Wiley Jones Co.	C, T
Colo.	Denver	Denver Fire Clay Co.	C
Fla.	Jacksonville	Jones Chemicals, Inc.	C, T
	Tampa	Tesco Chemicals, Inc.	C, T
Ga.	Atlanta	Tesco Chemicals, Inc.	C, T
	Savannah	Coastal Chemical Co.	C
Ill.	Chicago	Alexander Chemical Co.	C, T
Ind.	Beech Grove (Indianapolis)	John Wiley Jones Co.	C, T
Iowa	Burlington	McKesson & Robbins	C
Mo.	Kansas City	Thompson-Hayward Chemical Co.	C
N.J.	Maple Shade	Pioneer Chloramone Corp.	C
	Kearny	Marzahl Chemical Co.	C
	Newark	American Oil & Supply Co.	C
	Newark	E. M. Sergeant Pulp & Chemical Co.	C
N.Y.	Caledonia	John Wiley Jones Co.	C, T
N.C.	Charlotte	John Wiley Jones Co.	C, T
	Thomasville	Tesco Chemicals, Inc.	C, T
Pa.	Altoona	Western Pennsylvania Chem. Co.	C, T
	Lebanon	Lebanon Chemical Co.	C, T
	Philadelphia	Pennsylvania Salt Mfg. Co.	C, T
	Philadelphia	Pioneer Chemical Works, Inc.	C, T
S.C.	Spartanburg	Moreland Chemical Co.	C
Va.	Rosslyn	Peebles Chemical Co.	C
W.Va.	Belle	Belle Alkali Co.	C
Wis.	Milwaukee	Hydrite Chemical Co.	C, T

* C—Cylinders; T—Ton Containers.

Producers of Dry Hypochlorites

State	City	Producer
Mich.	Wyandotte	Pennsylvania Salt Mfg. Co.
N.Y.	Niagara Falls	Mathieson Chemical Corp.
Ohio	Barberton	Columbia-Southern Chemical Corp.

Manufacturers of Equipment for Feeding Chlorine and Hypochlorites

State	City	Manufacturer	Type of Equipment†
Calif.	Los Angeles	Paddock Pool Equipment Co.	Cl
Ill.	Chicago	Everson Mfg. Co.	Cl
Md.	Baltimore	Mathieson Chemical Corp.	H
Mass.	Somerville	Precision Machine Co.	H
N.J.	Newark	Wallace & Tiernan Co.	Cl, H
N.Y.	Buffalo	Manzel Brothers Co.	H
	Buffalo	Wilson Co.	H
	Leroy	Lapp Insulator Co.	H
	New York	Morse Boulger Destructor Co.	H
Pa.	Hatboro	Fischer & Porter Co.	Cl
	Philadelphia	Milton Roy Co.	H
	Philadelphia	Orchem Pump Co.	H
R.I.	Providence	Builders-Providence, Inc.	Cl
	Providence	Proportioneers, Inc.	H
Tex.	Dallas	Chlor-O-Matic Mfg. Co.	H

† Letters denote material fed: Cl—Chlorine; H—Hypochlorite.

d. Quantity which it is desired to purchase at this time.

e. The name of the firm or firms which have filled the more recent orders for chlorine.

f. A description of the efforts made to purchase chlorine, including the names of the firms which have refused to fill orders and their reported reasons for not filling orders.

2. *A catastrophe or emergency which results in immediate need of much larger quantities of chlorine than are on hand or immediately available.* Prior planning and preparation is essential to cope efficiently with an emergency which requires greater quantities of chlorine than are normally available. As a general rule, the executives of the local utilities or installations which are large sanitation users of chlorine, such as water and sewage treatment plants, will be a part of the local Office of Civilian Defense organization. The civil defense responsibilities to provide safe water and waste treatment during an emergency will include provisions to obtain needed quantities of chlorine.

Local agencies should initiate and carry out the necessary planning to assure that needed chlorine can be obtained. The following are believed to be essential components of such planning by the utilities:

a. An estimate should be made of the possible situations or conditions requiring the use of appreciable amounts of chlorine and the maximum quantity that may be needed.

b. A list of nearby stocks of chlorine should be developed. This list should include all organizations which usually maintain a stock of chlorine on hand, such as chlorine suppliers and repackagers, industrial users of chlorine, water plants, sewage plants, swimming pools, etc. The list should contain the following information with respect to each of the above stocks: [1] chlorine or chlorine compounds available; [2] size of containers; [3] quantity normally on hand which could be available for use in an emergency.

c. As a corollary to chlorine supply, equivalent information relative to chlorinating equipment which might be available for use in any emergency should be obtained. Swimming pools might be a particularly good source of smaller sizes of chlorinating equipment as frequently the pools may be inoperative or could be closed in an emergency.

In the event an emergency occurs the following general procedure should be followed:

a. The local and state health departments should be immediately informed and requested to supply as much needed assistance as possible.

b. The supplies of chlorine and chlorinating equipment sufficient for the immediate needs should be obtained from those sources previously listed which can spare them at the time.

c. As soon as the immediate exigencies of the situation have been met and estimates can be made of the chlorine requirements for the duration of the emergency or for a reasonable portion of the period which it is expected to exist, orders should be placed with regular suppliers. These orders should be for the amounts required in excess of the quantities loaned or obtained from other stocks plus that necessary to replace that loaned, unless other arrangements were previously made for replacement.

Suppliers

Table 4 lists known manufacturers of chlorinators and equipment for feeding hypochlorites; liquid-chlorine producers and repackagers in the United States, Canada, and Cuba; and producers of dry hypochlorites.

Management and Operation of Saginaw-Midland Water Supply System

By Alfred Eckert

A paper presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by Alfred Eckert, Mgr., Saginaw-Midland Water Supply System, Saginaw, Mich.

THE Saginaw-Midland Water Supply System furnishes raw water from Lake Huron for the cities of Saginaw and Midland, Mich. The facilities, jointly owned by the two cities, consist of 2 miles of 66-in. steel pipeline intake into Lake Huron, from which water is drawn at a depth of 41 ft. Whitestone Pumping Station, on the lake shore, delivers water through 48 miles of 48-in. prestressed concrete pipe to a booster pumping station known as Junction Station, where the flow is divided and measured through venturi meters on separate 36-in. branch pipelines to Saginaw and Midland, each city being approximately 15 miles from the booster station. The branch lines are owned and controlled independently by the respective cities.

The Whitestone or lake shore pumping station can deliver directly approximately 33 mgd to the cities, a rate that can be increased to 43 mgd by placing the Junction Station in operation. The lake shore pumping station is equipped with one 10-mgd and three 20-mgd pumping units using purchased electric power. Each unit consists of a single synchronous motor directly connected to two pumps in series. At a total head of 300 ft, this station was designed to deliver 43 mgd to the present booster station, which in turn will deliver a total of 43 mgd to the Saginaw and Midland branch lines.

The pumping equipment at Junction Station is identical with that at the lake shore station, except that each unit consists of a single pump, with provision for future installation of an additional pump in series when the system is expanded. There is also a 5-mil gal storage reservoir at Junction Station. Outlet connections for additional booster pumping stations have been built into the pipeline at the one-third dividing points in the line between the two existing stations, and the addition of the second pump to each unit at the existing booster station will increase the capacity of the system to 71 mgd.

This paper is concerned primarily with the management and operation of the jointly owned system. A detailed account of the physical structures of this project has previously been published (*1*).

Financing

Saginaw's share of the jointly owned facilities was financed through the sale of revenue bonds in the amount of $4,800,000, and the branch line was paid for with accumulated cash in the water fund. The Midland share of the joint facilities, as well as its branch line, was paid for out of the proceeds of a $6,-

000,000 bond issue. Bonds were sold and construction contracts were awarded in the fall of 1946, and the entire project was in operation in October 1948. Debt requirements are met by the two cities from rates and charges for water and services supplied.

The Dow Chemical Co., under an agreement made with Midland prior to the sale of bonds for the project, buys water directly from the Midland branch line. The company agreed to purchase not less than an average amount of 7 mgd, which made it possible for Midland to finance its share of the cost of the project.

When the design capacity of the system was being considered, Saginaw's rate of consumption was approximately 11.5 mgd and Midland's was assumed to be 10 mgd, including the minimum use guaranteed by the Dow Chemical Co. The initial plant capacity agreed upon was twice the then existing use, or 43 mgd, which could be expanded to 71 mgd by the addition of two future pumping stations. Financing costs of the jointly owned part of the project were divided 23:20 by Saginaw and Midland, in accordance with allocated design capacity. Neither city has the right to take more than its allocated amount of water from the joint system in any 24-hr period without securing permission from the other.

Board Control

Complete control, management, and operation of the system, subject to certain restrictions in the ordinance agreements, is vested in a board consisting of three men from each city, appointed by the respective councils for staggered 6-year terms. The board appoints the manager and fixes the salaries of all employees.

The two city councils have reserved to themselves the right to approve or disapprove the sale of water to any customer in a quantity exceeding 500,000 gal per month, and to provide for extensions and improvements to the system other than replacements. Funds for extensions and improvements must be furnished by the governing bodies of the two cities through the adoption of suitable resolutions. The board has no authority to borrow money for improvements.

The initial costs of operation were paid out of funds deposited with the board by the two cities. At the end of each calendar month the cost of operation for the month is computed as prescribed in the ordinance agreements, and the amounts are certified to the respective cities for reimbursement to the board. The total cost of water for the month is ascertained by adding to the actual labor, power, and miscellaneous operating expenses 0.25 cents per 1,000 gal of water delivered to the cities and one-twelfth of the total annual charge for interest and amortization. Any income from the sale of water to customers other than the cities of Saginaw and Midland is deducted to arrive at the total cost.

The cities also agreed that their respective actual interest costs would be added to the construction expenses for the purpose of determining monthly amortization costs, provided that the difference in interest rates in the two cities did not exceed 0.5 per cent. Saginaw bonds sold at 1.86 and Midland at 2.13 per cent. As the difference in interest rates is only 0.27 per cent, total amortization costs for both cities are proportioned on the basis of water use. After the apportionment has been made, each city's monthly

share of interest and amortization for its part of the indebtedness incurred for the joint system is deducted, and the remainder is billed by the board to the cities. Because the indebtedness incurred for its share of construction costs for the system is an obligation on each city, these costs are added to the monthly operating expenses before apportionment and are then deducted to arrive at the net monthly billing to each city.

The money received by the board from the two cities by reason of the payment of 0.25 cents per 1,000 gal is kept in separate funds to the credit of each city and may be used for improvements to the joint system or for emergency replacements or repairs, subject, however, to approval by the respective city councils.

Operation of System

Many outlets for service connections were built into the pipeline at points where it was considered water service might be desired in the future. Water connections are sold to individuals and to organized communities, including small metropolitan districts along the line. The water is chlorinated at the source and is approved by the Michigan Dept. of Health for individual residential use without filtration. Organized communities, however, are required to employ filtration.

In order to provide service connections along the line, most of which lies within the highway right of way, it has frequently been necessary to install tapping assemblies furnished at nominal cost by the pipe manufacturer.

The prestressed concrete pipeline is remarkably free from leaks, and there is practically no unaccounted-for water. Owing to the limits of accuracy of venturi meters, they normally record slightly more water going into the two branch lines than is delivered to these lines from the lake shore pumping station above.

A number of momentary purchased-power failures due to electrical storms have occurred. There have also been several interruptions of longer duration, caused by electric transmission line troubles. In November 1952, a deer hunter's shot shattered an insulator on the power company's high-tension line, which caused a momentary power failure at the Whitestone Pumping Station, 40 miles away. A resultant surge in the branch line more than 50 miles from the station ruptured one 16-ft length of 36-in. prestressed concrete pipe on each line. Pressure gages on each end of the 15-mile branch lines failed to record any unusually high pressures, nor did the surge relief valves open. Although the wire reinforcing around the pipe broke and the steel cylinder opened up for a few feet, the lines, in spite of considerable leakage, were kept under pressure and in service for several days before arrangements were made to replace the broken sections of pipe.

Upon completion of the project, tests of the hydraulic efficiency of the pipelines were made. The 10,420-ft, 66-in. steel intake pipe, lined with spun coal-tar enamel and having mechanical couplings at 120-ft intervals, was found to have a Hazen-Williams coefficient of about 130. The 253,500 ft of 48-in. prestressed concrete pipe had a coefficient of approximately 145. The Saginaw branch line (71,900 ft of 36-in. prestressed concrete pipe) and the Midland branch line (71,000 ft of 36-in. and 15,500 ft of 24-in. pipe) each had a coefficient of approximately 140.

The lake shore pumping station is manned by two operators on each of three 8-hr shifts, which are rotated weekly, and two additional operators provide the necessary relief during off-days for regular operators. An electrician supervises the operators and performs such electrical maintenance as may be required at both pumping stations. A total of nine men are employed at the lake shore station.

The Junction Station is operated during peak periods when the lake shore station capacity to deliver directly to Saginaw and Midland is insufficient or when there is a power failure at the latter station. One operator is on duty at Junction Station for five 8-hr periods during the week. The business office is also located there. It has so far been found satisfactory to use Whitestone operators on their off-days to provide the necessary manpower to operate Junction Station as needed. In 1952 this station was operated only on 24 days, for periods ranging from 1 to 24 hr.

The Whitestone Pumping Station is located on the Lake Huron shoreline, approximately halfway between Au Gres and Tawas City, Mich. Operators for this station were recruited from available personnel in the area and within a comparatively few miles of the station. A number of these men were employed by the contractors during construction and have developed into first-class operators.

Construction and major repair work is handled by crews requisitioned from Saginaw and Midland, or by local contractors.

Reference

1. Howson, L. R. & Kneer, V. R. Saginaw-Midland Water Supply Project. *Jour. AWWA*, **41**:139 (Feb. 1949).

Potable-Water Storage Reservoirs

Committee Report

A committee report presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by Elwood L. Bean, Chairman, Committee E5.7—Open-Air Reservoirs; Chief, Water Treatment Sec., Philadelphia Water Dept., Philadelphia. Other members of the committee were: R. L. Derby, E. B. Evans, and W. J. Scott.

This document has been approved for publication by the AWWA Board of Directors, as well as by the Committee on Water Works Practice, with reservations recorded by a competent minority. These reservations may be expressed as follows: The subject of potable-water storage reservoirs, their construction and protection, is one upon which a variety of opinions may exist; used and useful reservoirs which do not conform to the letter of the recommendations of the committee are in service; and, although the report is an essential consensus among the advanced thinkers in the industry, its terms are to be taken as recommendations rather than mandates.—EDITOR

THE scope of this report includes all reservoirs to which there is conveyed for storage, either of short or long duration, water of a quality considered suitable and intended for direct discharge to a potable-water distribution system. Natural or artificial stream-fed lakes or impounding reservoirs are excluded. It is immaterial whether the water to be stored has been derived from a pure underground source, has been conveyed from some isolated surface source considered to require no treatment, or is the effluent from a water treatment plant or process. It is also immaterial whether the reservoir is a treatment plant "well" or "filtered-water basin" adjacent to the plant, or a "distribution" reservoir built at or near ground level, within or outside the distribution area, for gravity distribution or for repumping.

Because these reservoirs receive and are intended to discharge potable water to the distribution system, they should be so designed and constructed that the water retained does not suffer physical, bacteriological, or chemical deterioration. A structure that is water- and light-tight, with the bottom above the ground water table, with the ground surface graded for proper drainage away from the reservoir, with a cover aboveground or of proper design and buried under the earth, can provide insurance against deterioration.

On the other hand, uncovered reservoirs expose waters to possible deterioration and contamination, potentialities that should not be ignored. The extent of these effects will vary widely, depending upon many physical and climatic conditions. Outlet treatment can, in part, make up for the inadequate protection afforded by the uncovered reservoir. As will be further discussed and indicated elsewhere in

this report, it is the opinion of the committee that efforts should be made to provide supplementary treatment of all outlet water from uncovered reservoirs unless ample residuals of a disinfecting agent are at all times carried through the reservoir.

With the foregoing in mind, throughout this report the reservoirs under discussion will be referred to simply as "open" or "covered."

In 1947 questionnaires were sent by the committee to all state and provincial engineers in the United States and Canada. Of the 56 questionnaires sent, 53 were returned, representing 94.6 per cent. The results can therefore be regarded as reflecting opinions existing throughout the two countries. Appended to this report is a summary of the replies received.

The respondents unanimously preferred covered reservoirs and agreed that existing reservoirs should be covered whenever practical; 90 per cent did not "consider it impractical to recommend that all future installations be covered"; 80 per cent did not officially approve of open reservoirs, and others did not personally approve of them. All stated that open reservoirs should be fenced, and 98 per cent believed that public recreation should not be permitted on the grounds of such reservoirs.

Pollution and Deterioration

The replies indicated that there was widespread pollution of open reservoirs, due to gulls, ducks, and other birds; to animals and rodents, such as dogs, cats, mice, rats, and frogs; to windblown and atmospheric contaminants; to humans, from bathing, fishing, and drowning; and to numerous other sources. Correspondence shows that night swimming and fishing, particularly in large or isolated reservoirs, were extremely difficult to prevent, even with fences and watchmen. Wires strung across reservoirs to keep gulls and ducks away have provided perches for swallows, starlings, and other small birds.

Plankton growths were noted by many. Their development was particularly stimulated by sunlight in waters containing ammonia or chloramines, high nitrates, carbonates, phosphates, carbon dioxide, or iron. Other conditions mentioned as favorable to plankton growth were shallow areas, poor circulation, and rough-surfaced walls of earth, clay, rock paving, or similar materials.

Obviously, properly designed and constructed covers would eliminate the causes of direct pollution previously noted. Indirect pollution in open reservoirs can be met by providing flow-through circulation and by treating the influent and stored water. Despite such measures, however, unsatisfactory conditions have not infrequently developed in open reservoirs.

Covering of Reservoirs

Consideration should be given to the question of whether the water in open reservoirs, properly controlled and disinfected, can be considered as, at all times, meeting present standards of bacteriological safety, physical quality, microorganism content, and palatability. Assuming correct application of a disinfecting medium at the reservoir outlet, with reasonable contact before the water reaches the consumer, an affirmative answer may be made with regard to its bacteriological safety. In view of the many possible sources of pollution and causes of deterioration, however, one might well hesitate to give other than a negative answer with regard to the other three items.

Most water works authorities have expressed themselves as favoring the covering of reservoirs. The costs of such a procedure may seem high when taken alone, but they should be considered in the perspective of the protection given and in relation to the total costs of providing water. Addition of one-fifth to the cost of a reservoir in order to provide a cover may mean only a small percentage increase in the total cost of providing water, or even in the total cost of treatment facilities. In some instances, capitalization of the annual costs of effluent treatment on an open reservoir, plus the salaries of watchmen, may equal the cost of covering the reservoir. Assuming effluent treatment facilities need to be provided for the open reservoir, their cost may be subtracted from the cost of covering it.

The surface areas over covered reservoirs may be made community assets in the form of municipal service building sites, scenic spots, beautiful park lands, tennis courts, or athletic fields. Developments at Grand Rapids, Mich.; Ventura and Beverly Hills, Calif.; and Arkansas City, Kan., furnish examples. It is interesting to note that, in Los Angeles and San Diego, Calif., unpleasant public relations have been caused by objections of neighbors to the covering of reservoirs. Beautification of covers may be the proper solution.

The size of existing open reservoirs may be a very important factor in the practicability of covers, particularly where the reservoir bottom is presently only puddled clay or a shallow layer of impervious soil. The use of lightweight metal covering materials may make covers practical at many such installations.

The size of a new potable-water storage reservoir, in the opinion of the committee, should not be a controlling factor as it would have little effect on the relative cost of covering, if foundation conditions are uniform and earthquake safeguards are not necessary. To meet foundation problems, new construction designs have been evolved; at Long Beach, Calif., eighteen steel tanks were constructed on specially prepared foundations to provide 60 mil gal of storage aboveground.

Recent attempts to reduce costs of covered structures below those of the old standard designs have resulted in many innovations. These include prestressed concrete tanks with a thin, gunited dome roof, which have been constructed up to 5-mil gal capacity; steel tanks with plywood roofs on steel girders, as at Long Beach; all-welded steel reservoirs up to 10-mil gal capacity; and concrete reservoirs with roof slabs supported by 4-in. cast-iron pipes, up to 7-mil gal capacity.

Published data indicate that the cost of a new covered reservoir of the type dealt with in this report is generally 15–20 per cent higher than that of an open reservoir.

Information on 73 reservoirs constructed between 1900 and 1930 and on 43 other reservoirs constructed between 1920 and 1952 indicates that, in the first period, 2.0 covered reservoirs were constructed for each uncovered reservoir, while, in the second period, the ratio rose to 4.4, showing a distinct trend toward covered reservoirs.

Limitations of Existing Reservoirs

One of the principal influences on water quality in open reservoirs is the amount of circulation in the reservoirs, including flow-through, wind action, and similar factors. The majority of older reservoirs "float" on the distribution system, and the average amount of

fill and draw may indicate a total displacement no oftener than once in 30 days. Where the inflow and outflow are through a common connection, circulation cannot be improved (except, perhaps, to a limited extent by increasing the amount of fill and draw) unless another connection is provided, with checks to prevent flow reversals. Even with such directed flow, a low rate of flow-through is usually undesirable.

Sloping walls of earth or walls faced with rocks, bricks, blocks, or other materials with open joints are undesirable as they encourage the growth of weeds and algae, present ideal conditions for such small animals as crayfish, and allow rodents to work freely.

Open reservoirs of shallow depth with low rates of flow-through are particularly subject to difficulty with algae growths.

Barring of Public

Opinion seems to be nearly unanimous that open potable-water storage reservoirs should be fenced and that the public should be barred from the immediate areas surrounding them. Experience has shown that even a 9-ft fence topped with barbed wire will not keep out those determined to enter a reservoir. It is therefore futile to depend too much on a manproof fence; persons who wish to enter will go over the top or cut through. A fence should be of such material and construction as will prevent the passage of children and such animals as dogs, cats, and rabbits, and will discourage the less determined youths from pranks. The fence should be placed at a sufficient distance from the water to eliminate the pleasure found in watching things thrown in the water. Access gates should, of course, be locked.

Drainage should always be provided and should be ample to convey surface waters away from all reservoir edges.

Many kinds of recreation may be allowed outside the fence (provided the conditions mentioned have been fulfilled), particularly the various types of grass court games. Dirt driveways or walks, dirt tennis courts, ball fields, pony concessions, or other public activities that might create dust bowls should, however, be prohibited in the vicinity of open reservoirs.

Disinfection of Water

A substantial amount of pollution is not uncommon in open reservoirs. There are few sanitarians who will not agree that treatment of the effluent of open reservoirs is desirable in order to meet present-day standards of quality, unless chlorine residuals are present and are carried through the reservoir. Approximately two-thirds of those replying to the questionnaire thought residuals could be carried through reservoirs, but an equal number stated that disinfection facilities should be set up so that all water reentering the distribution system would be retreated. Therefore, many who consider that residuals can be maintained indicated they believe provision of disinfection facilities should not be omitted at reentry to distribution.

A striking example of the need for such treatment is found in the data on four open reservoirs of one water system. The reservoir effluent waters showed monthly averages of 35–100 per cent of 10-ml portions positive for coliform organisms, with 28–100 per cent of the samples showing three or more of the five portions positive. Flow-proportional chlorination produced samples well within the limits set by public health standards.

Chlorination facilities should be designed and operated, and chlorination should be controlled, in accordance with the best approved modern practices at treatment plants and other points where water is fed into the distribution system.

Reservoir Construction Materials

Many of the reservoirs now in use were constructed long before present standards of water quality were evolved and before the aesthetic demands of consumers had reached present heights. These reservoirs were frequently built of materials that make it difficult to maintain present standards even if the reservoirs are covered. For instance, construction of the slope, face, or walls using wood timber, brick, fieldstone or stone blocks, with unsealed or impermanently sealed cracks, affords great opportunities for trouble to develop. Rodents may infest the walls and cause, both directly and indirectly, pollution of the water and partial destruction of the walls. Open cracks or irregular surfaces encourage growths of algae, weeds, and bushes, as well as presenting ideal habitats for crayfish and other undesirable aquatic life. Development of microscopic organisms is also aided by the existence of wall surfaces composed of any rough material. Construction of new reservoirs having wall surfaces of other than smooth concrete, smooth, well set and mortared brick or tile, or coated metal cannot be recommended. Existing reservoir walls with surface irregularities or cracks may, if structurally sound, be transformed by modern engineering techniques, such as the high-pressure application of concrete, to produce continuous smooth surfaces.

Covers on reservoirs must, of course, be structurally sound in order to withstand wind pressure, snow and ice, earthquake strains, and the like. Moreover, the materials should be and continue light-tight (certain types of wood covers do not long remain so) and impervious to dust and polluting agents. Many old, small reservoirs were covered by roofs of V-type, timber, board, and shingle construction like that common in house roofs. The utilization of plywood panels on steel rafters for covering eighteen steel tanks at Long Beach, Calif., has already been referred to. Such covers can be satisfactory, if properly designed, so long as they receive sufficient maintenance. More usual and more permanent covers are those of so-called standard concrete, light-weight concrete dome, and steel construction. If the reservoir is to be buried under earth, only the "standard" cover designs are generally practical. For those not to be buried, the light-weight concrete dome and the steel covers are practical.

Salient Protection Features

1. Storage reservoirs should preferably be located and constructed at elevations above ground water levels, high enough to avoid possible flooding or inundation from surface streams or storm waters. Structures and appurtenances should be of "watertight" construction throughout the floor and wall areas. As even such construction may not always be, or remain, free from small leaks, where there is a possibility that ground water gradients will rise above the reservoir floor level, steps should be taken to keep the ground water free from pollution in the vicinity of the reservoir.

2. The ground surface about the reservoir, or coverage over the reservoir, should be sloped to drain or divert surface water away from the reservoir and should be so graded that

no pooling of surface water will occur in the vicinity.

3. Overflow, blowoff, or cleanout pipes should discharge freely, without opportunity for backflow of contaminated water or material. If the discharge is to a control chamber so located as to overflow above ground and flood level, it may be drained by gravity directly to the ground surface or indirectly into a storm drain; otherwise it should be drained by pumping. In covered reservoirs, the discharge ends of all overflow, blowoff, or cleanout pipes should be turned downward and screened to prevent the entrance of rain, dust, birds, insects, rodents, and other contaminating materials.

4. Where practical, a suitable and substantial cover should be provided for any reservoir, elevated tank, or other structure used for water storage. Covers should be watertight, generally light in weight, of durable materials and construction, and designed to provide drainage from the cover and to prevent the entrance of contaminating materials into the stored water.

5. Manholes, when necessary on covers over storage reservoirs, should be fitted with raised, watertight walls projecting at least 6 in. above the level of the reservoir cover or of any fill material placed over the cover. Each manhole should be closed with a solid, watertight cover, preferably with edges projecting downward at least 2 in. around the outside of the frame. Each manhole cover should be provided with a sturdy locking device and should be locked at all times except when in actual use.

6. Any necessary vents or openings through covers on storage reservoirs, for water level control gages or other purposes, should be so constructed and screened as to prevent the entrance of dust, rain, snow, birds, insects, or other foreign material.

7. Storage reservoirs should be operated at all times in such a manner as to maintain the highest sanitary quality of water.

Cleaning Procedures

Ordinarily reservoirs are entirely emptied before cleaning operations are started. In such instances, the reservoir should be entirely isolated from the system to avoid any possibility of contaminating materials entering distribution. Means of removing materials from the reservoir are varied and should be selected by the individual responsible for the cleaning. The procedure adopted should be one which will: [1] remove all deposits of whatever nature; [2] remove all growths; [3] clean the walls, slopes, and bottom; [4] do no damage to walls, slopes, or bottom; [5] avoid pollutional or oil deposits by work animals, workmen, tractors, or other equipment.

If hydraulic dredging is employed in cleaning a reservoir, complete isolation from the system may not be required. Isolation is very desirable while the dredge is operating in the vicinity of the outlet, but at other times a comparatively low draft to the system may not be objectionable. All outlet water should be amply disinfected during such operation to prevent possible contamination of the distribution system.

Disinfection Procedures

Several methods have been used to disinfect reservoirs after cleaning. One procedure is to spray all surfaces with a strong chlorine solution. Certain water works have made a practice of refilling the reservoir with a quantity of water (say, 5 per cent of capacity), treated with 50–100 ppm chlo-

rine. After this water has been allowed to stand overnight, the reservoir is filled to full capacity, the water is again permitted to stand overnight, and the reservoir is then placed in operation. The bottom may have the greatest pollutional load and is therefore subjected to the most concentrated dosage. It may well be questioned whether the sides are properly disinfected. The water quality should always be checked by bacteriological or chlorine residual tests, or both, before the water is allowed to enter the system.

The committee believes that it is good practice to fill the reservoir to maximum level with potable water treated with approximately 50 ppm of chlorine, drain away the disinfecting water after contact, refill with potable water, and make bacteriological checks on the refilled reservoir before connecting it to the system. It is recognized that such a procedure is often not practical and sometimes may even be hazardous because of the lack of fire supply reserve. It is felt, however, that the water works official should give serious consideration to the possibilities of carrying out a complete disinfection check, particularly if ample disinfection of the reservoir outflow is not provided.

A laboratory check on reservoir water quality should consist of tests on several samples collected from various points in the reservoir. The tests should determine its compliance with quality standards for potable water in use throughout the system. If properly controlled chlorination of all effluent water is practiced, some tolerance may be allowable in the results of these tests.

Conclusions and Recommendations

The committee members believe—and the conclusion is supported by the questionnaire results—that few open reservoirs can continuously deliver satisfactory water with physical, bacteriological, and biological qualities meeting present-day standards.

The U.S. Public Health Service *Manual of Recommended Water-Sanitation Practice*, prepared in 1946, recommended that "no unprotected open reservoir . . . should be permitted." If "unprotected" is interpreted to mean absence of fencing and other safeguards, the committee agrees that the use of such reservoirs should be prohibited.

The committee does not believe that the use of all open reservoirs need be prohibited. However, facts already known and information received from questionnaires are such that the committee feels both justified and obligated to make a strong recommendation for:

1. The covering of all potable water storage reservoirs to be constructed in the future.

2. The serious consideration by individual water works officials of these possibilities, in order of preference: (a) covering each existing open reservoir in the not too distant future; or (b) providing automatic * disinfection of all water drawn from any open reservoir, unless an ample residual of a disinfecting agent is at all times carried through the reservoir to the distribution system.

* In certain installations where flow changes are never rapid, manually controlled chlorination, with continuous attendance and recording chlorine residual devices, may be considered the equivalent of automatic disinfection.

APPENDIX

Results of Questionnaire

Question	Replies			Comments
	Yes	No	Doubtful	
General				
1. Do you approve of open storage reservoirs on distribution systems?	10	43		Two engineers of the 10 answering "Yes" personally disapprove, though officially approving. In 1 state, no new reservoir of open type is approved; existing open reservoirs must maintain chlorine residual in the reservoir or rechlorinate the outflow.
2. Apart from economics, would you prefer covered to uncovered reservoirs?	53	0		
3. Do you consider it impractical to recommend that all future installations be covered?	2	48	3	Question was raised on large reservoirs; others stated action should be confined to recommending, not requiring.
4. Should existing reservoirs be covered whenever practical?	53	0		"Whenever practical" was emphasized by some.
5. If uncovered, should the reservoir be surrounded by a high wire or other type of fence?	53	0		Inadequacy of a fence alone was emphasized by many.
6. Should the grounds of uncovered reservoirs be barred to the public for recreational purposes as a safety measure?	52	1		Many indicated that grounds immediately around the reservoirs could be protected by fencing, surface drainage, and guarding, and areas outside could be used for recreation.
Covers				
7. Does the type of cover used permit drainage or rain water to enter?				A considerable number answered in the affirmative.
8. Is the cover watertight?	34	13		At least 6 of those answering "Yes" qualified their replies by mentioning hair cracks, vents and breathers, overflows, manholes, etc.

Question	Replies			Comments
	Yes	No	Doubtful	
9. Have you experienced pollutional trouble as a result of small animals entering covered reservoirs?	31	17		Several answered "No" but indicated that undoubtedly such pollution had occurred. Among animals reported as found in covered reservoirs were mice, frogs, tadpoles, and some birds.
Pollution of Open Reservoirs				
10. Atmospheric pollution by means of chemicals has been reported in England. Do you know of any instance in America, particularly in industrial areas?	4	49		Pollutants reported included chemicals from orchard spraying, sulfur dioxide and arsenous oxide from mining districts, and ashes and cinders from trains.
11. Windblown contamination includes a large number of substances, many of which cause bacterial pollution. There appears to be no answer to this problem other than covering all reservoirs. Please give your comment on this.				22 stated that all reservoirs should be covered as the only means of preventing such contamination. Some indicated adequate chlorination to be the answer. Others suggested hedges, screens of conifers, etc. Many reported experience with heavy contamination by animal fertilizers, seeds, grass, and pine pollen which caused diarrhea.
12. *Human pollution.* (Under this heading, malicious contamination could consist of the deposition of either chemical or bacterial substances capable of causing widespread injury to consumers. Likewise, bathing could cause serious infection, particularly if the bather were a carrier. Fishing is always potentially dangerous and objectionable.) Have you experienced any bathing or fishing within your zone of jurisdiction? With the exception of covering, have you any suggestions to offer that would guard against such conditions?				Drownings were reported; swimming by boys was a common prank; night swimming was not stopped by a 9-ft fence. The consensus was that it is difficult to control remote reservoirs effectively without night watchmen, floodlighting, and patrolling. One respondent stated that even night watchmen were not reliable.
13. *Fish.* The chief objection to fish is the invitation to illegal fishing. Your comment on this would be appreciated.				Comments indicated a feeling that the benefits of fish in reservoirs were more than offset by the difficulty of preventing fishing, and that fishing should not be permitted because of resultant contamination.

Question	Replies			Comments
	Yes	No	Doubtful	
14. ***Animals and birds.*** Domestic animals are frequently seen in the vicinity of reservoirs and can be found drinking or swimming in the water. Gulls, ducks, pigeons, and some other birds frequent open reservoirs. Suggestions are requested as to how to deal with this problem.				Many considered this source of pollution a serious problem, indicating trouble from ducks, frogs, migratory fowl, pigeons, sea gulls, other birds, beavers, tadpoles, dogs, cats, squirrels, rats, and mice. Suggestions were: fencing, shooting at intervals, and stringing of wires, electrically charged or with cloth flags to frighten birds. There were no definite indications that the latter methods were effective.
Plankton Life				
15. Plankton life includes a fairly extensive field and can constitute a great nuisance. Exclusion of sunlight appears to be the only answer. Do any special types of reservoir construction produce possible adverse effects?	*	27		Comments of 18 on open reservoirs noted adverse effects from shallow areas, sloping walls, earth bottoms, poor circulation, earth, clay, rock-paved, wood or other rough-surfaced banks.
16. Do any special kinds of water give certain troubles of a chemical or other nature that can be guarded against?	*	33		Comments noted that, in presence of sunlight, waters treated with ammonia for chloramine encourage plankton growths, as do ground waters high in nitrates, carbonates, carbon dioxide, or iron.
17. Is it necessary to make tests at certain intervals of time to detect changes that spell trouble, notably the calcium carbonate chemical balance or stability?	23	30		Comments were somewhat confused; only a few indicated any serious belief that the chemical tests referred to would be of particular values.
18. Should certain treatment procedures be used to care for such difficulties as microscopic growths?	47			Free residual chlorine, chloramine, copper sulfate, and activated carbon were suggested for control in open reservoirs.

* See "Comments."

Question	Replies			Comments
	Yes	No	Doubtful	
Reservoir Cleaning				
19. Should special disinfection procedures be followed when reservoirs are emptied?	42	7		In general, it was indicated that open reservoirs, or any reservoir if it has been entered, should be disinfected before reuse. Some mentioned tests; others suggested disinfection only if test results were unsatisfactory.
20. Should any special procedures be prescribed for emptying, cleaning, and refilling, with special reference to testing before reservoir is placed in commission again?	47	6		Spraying with strong chlorine solution or refilling with water containing 50 ppm chlorine was suggested. Deferring use of reservoir until bacteriological tests could be made was generally thought to be impractical, although conceded to be desirable.
Effluent Water Quality				
21. How often are control tests made on the quality of water leaving service reservoirs?				Only 24 indicated that tests are made with any degree of regularity. Frequency of testing varied from daily to none at all. Many indicated reliance on tests throughout the distribution system rather than at a reservoir outlet.
22. Is it feasible to carry chlorine residuals through such reservoirs, especially those of small area?	34	9	10	It was generally thought that residuals may be more easily carried through covered reservoirs. In open reservoirs, free or combined chlorine residuals may be maintained if the reservoir is of the flow-through type and its size is not too large in relation to the flow.
23. Should disinfection facilities be set up so that all the water reentering the distribution system will be re-treated?	31*	*		6 thought this desirable; 6 indicated it was impractical; 8 said, "No, if the reservoir is covered." None replied "No" with definite regard to open reservoirs.

* See "Comments."

Proposed Revision of Utility Accounting System

Committee Report

A committee report presented on May 12, 1953, at the Annual Conference, Grand Rapids, Mich., by J. J. Barr, Chairman, AWWA Committee to Cooperate With NARUC Committee on Accounts and Statistics; Vice-Pres., Water Utilities Service Corp., Philadelphia. Other members of the AWWA committee were: A. L. Houlehin, J. F. Kavanagh, A. P. Learned, L. L. Leonard, Harry Reinhardt, R. L. Swingley, and Russell Van Horn.

THE purpose of this brief report is to outline the work of the Association committee appointed to cooperate with the Committee on Accounts and Statistics of the National Assn. of Railroad and Utility Commissioners (NARUC) in the revision of the uniform system of accounts for water companies. Approximately 2 years ago the NARUC committee was instructed to undertake the drafting of revised systems of accounts for electric, gas, and water utilities. Its objective has been to prepare and present for adoption by the NARUC a classification which will be uniform for all such utilities in as many respects as possible. To the end that the viewpoints of all interested parties might be represented in the NARUC committee's considerations of the electric and gas systems, which were given priority, it solicited participation by representatives of the Edison Electric Institute, the American Gas Assn., the Federal Securities and Exchange Commission, the Federal Power Commission, and the American Institute of Accountants.

As the committee progressed to the revision of the water system, the AWWA was invited to appoint a committee to confer with a subcommittee of NARUC. The AWWA committee became active in the early part of July 1952.

A tentative draft of the revised system of accounts has been completed. The balance sheet and income accounts are to be essentially identical for the three classes of utilities. Extensive changes in the classification of accounts have been agreed upon and are included in the current draft. Only the more important revisions are outlined in the present report.

Classification of Utilities

The proposed system has been set up for four classes of utilities, as against only three classes in the present system of accounts. The minimum annual water operating revenue for Class A utilities has been increased from $250,000 to $750,000. Utilities with annual operating revenue exceeding $250,000 but not more than $750,000 fall in Class B; those with annual revenue exceeding $100,000 but not more than $250,000, in Class C; and those with annual revenue exceeding $25,000 but not more than $100,000, in Class D.

Accounts and Records

Original-cost accounting and continuing property records. Utilities sub-

ject to the proposed classifications will be required to record utility plant accounts on the well-known original cost basis, and Class A and B utilities—that is, those with annual revenues in excess of $250,000—will be required to maintain continuing property records in which the amounts of annual additions, retirements, and the balance of each plant account are classified to show the number and cost of the various retirement units. There has been extensive discussion of the burden that this requirement might impose on the water utilities and the AWWA committee has been assured that considerable latitude in the maintenance of these records will be allowed, to the end that they may be simplified and not too costly. The system of accounts contains no requirements or specifications for the form or type of records to be maintained, in order to avoid conflict with adequate records which may have already been developed.

Depreciation and related reserves. The proposed classification provides for straight-line depreciation unless otherwise specifically authorized by the commissions adopting the system. The NARUC committee originally proposed a segregation of the reserve, now described as "accumulated provision for depreciation (amortization)," by plant accounts, but later modified this requirement so as to provide for segregation of the accumulated depreciation by functional plant groups—source of supply, pumping, water treatment, and the like.

Utility plant accounts. The major change in the utility plant accounts for water utilities is in the classification of mains according to their primary functional use: supply, transmission and distribution, and fire. Supply mains are those which convey water to a unit in the source of supply, water treatment, or pumping plant and which generally provide no service connection with customers. Transmission and distribution mains are those the primary purpose of which is to convey water requiring no further processing, except incidental chlorination or pressure boosting. A fire main is one used exclusively for fire protection purposes.

Contributions in aid of construction. The NARUC committee originally proposed that contributions from customers be credited to the utility plant accounts instead of being included in a separate contribution account as at present. This proposal has been modified to provide that the presently prescribed procedure be followed; provided, however, that a proposal of a utility to credit contributions to the plant accounts may be authorized by the commission having jurisdiction.

Retirement units. It is proposed that, for the time being, the present NARUC list of retirement units, which was adopted in 1938, be continued, with the understanding that early consideration will be given to suggestions for revisions that may be required upon the adoption of the proposed classification by the NARUC.

Revenue and expense accounts. The number of accounts required for all classes of water utilities has been reduced materially, with the understanding, of course, that any utility may provide subdivisions of these accounts if it so desires.

The definition of miscellaneous source-of-supply expenses has been amended to include the cost of unproductive or unsatisfactory wells drilled as a part of a project which results in a supply of water within the same source-of-supply or distribution area. Some existing classifications provide,

in effect, for charging such cost below the line and not as an ordinary or necessary operating expense of a water utility. This apparent inequity appears to be corrected by the proposed amendment. It would seem reasonable to assume that a utility will be able to obtain permission from a commission to amortize such costs as a source-of-supply expense over a period of years if the amount is sizable. Because the present draft is not entirely clear on this matter, the AWWA committee will endeavor to have the related provisions of the classification defined so that such treatment may be clearly permitted.

Statement Forms and Terminology

To afford a comparison with presently prescribed statement forms and terminology, there is appended to this report lists of account titles contained in the latest drafts of the revised system. It should be noted that the accumulated provisions for depreciation (amortization) must be deducted from the plant account on the balance sheet. The credit for interest during construction is now classified as "other income" instead of a reduction of interest charges.

In conformity with recent changes in the Federal Securities and Exchange Commission Form S-X and bulletins of the American Institute of Accountants, the proposed system provides for the so-called "all-inclusive income statement." This is accomplished by first arriving at a figure for net income and then giving effect to special items in two new accounts—"special income charges" and "special income credits." The resulting balance is described as "net income and special items." The term "retained income" has been adopted as a substitute for "earned surplus."

The entire membership of the NARUC committee has extended to the AWWA committee full opportunity to express suggestions and criticisms. Its ideas have been fully considered and for the great part accepted. The AWWA committee therefore feels that it should be authorized to continue its work, at least to the point of adoption by the NARUC of the new system of accounts.

APPENDIX A

Balance Sheet Accounts—Assets and Other Debits

1. Utility Plant

101. Utility Plant in Service
102. Accumulated Provision for Depreciation and Amortization of Utility Plant in Service
103. Utility Plant Leased to Others
104. Accumulated Provision for Depreciation and Amortization of Utility Plant Leased to Others
105. Property Held for Future Use
106. Accumulated Provision for Depreciation and Amortization of Property Held for Future Use
107. Construction Work in Progress
108. Utility Plant Acquisition Adjustments
110. Other Utility Plant Adjustments

2. Other Property and Investments

121. Nonutility Property
122. Accumulated Provision for Depreciation and Amortization of Nonutility Property
123. Investment in Associated Companies
124. Other Investments
125. Special Funds

3. Current and Accrued Assets

131. Cash
132. Working Funds
133. Temporary Cash Investments
134. Special Deposits
135. Notes Receivable
136. Accounts Receivable

137. Receivables From Associated Companies
138. Materials and Supplies
139. Prepayments
140. Other Current and Accrued Assets

4. Deferred Debits

151. Unamortized Debt Discount and Expense
152. Extraordinary Property Losses
153. Other Deferred Debits

Balance Sheet Accounts—Liabilities and Other Credits

5. Proprietary Capital

201. Common Capital Stock
202. Preferred Capital Stock
203. Other Paid-in Capital
204. Installments Received on Capital Stock
205. Discount on Capital Stock
206. Capital Stock Expense
207. Appropriated Retained Income
208. Unappropriated Retained Income
209. Reacquired Capital Stock

6. Long-Term Debt

211. Bonds
212. Advances From Associated Companies
213. Miscellaneous Long-Term Debt

7. Current and Accrued Liabilities

221. Notes Payable
222. Accounts Payable
223. Payables to Associated Companies
224. Customers' Deposits
225. Taxes Accrued
226. Interest Accrued
227. Other Current and Accrued Liabilities

8. Deferred Credits

241. Unamortized Net Premium on Debt
242. Customers' Advances for Service
243. Other Deferred Credits

9. Operating Reserves

251. Property Insurance Reserve
252. Injuries and Damages Reserve
253. Pensions and Benefits Reserve
254. Other Reserves

10. Contributions in Aid of Construction

261. Contributions in Aid of Construction

APPENDIX B

Income Accounts

1. Utility Operating Income

401. Operating Revenues
Less Operating Expenses:
402. Operation Expense
403. Maintenance Expense
404. Depreciation Expense
405. Amortization Expense
406. Taxes Other Than Income Taxes
407. Income Taxes
Net Operating Revenues
421. Income From Utility Plant Leased to Others
Utility Operating Income

2. Other Income

431. Income From Merchandising, Jobbing, and Contract Work
432. Income From Nonutility Operations
433. Nonoperating Rental Income
434. Interest and Dividend Income
435. Interest Charged to Construction—*Credit*
436. Miscellaneous Nonoperating Income
Total Other Income
Total Income

3. Miscellaneous Income Deductions

441. Miscellaneous Amortization
442. Other Income Deductions
Total Income Deductions
Income Before Interest Charges

4. Interest Charges

451. Interest on Long-Term Debt
452. Amortization of Debt Discount and Expense
453. Amortization of Premium on Debt—*Credit*
454. Interest on Debt to Associated Companies
455. Other Interest Charges
Total Interest Charges
Net Income

5. Special Items

461. Special Income Charges
462. Special Income Credits
Net Income and Special Items

6. Retained Income

208. Unappropriated Retained Income (at beginning of period)
471. Balance Transferred From Income
Total

472. Dividend Appropriations—Preferred Stock
473. Dividend Appropriations—Common Stock
474. Other Appropriations of Retained Income
475. Miscellaneous Debits to Retained Income
Total Debits
208. Unappropriated Retained Income (at end of period)

APPENDIX C

Utility Plant Accounts

A. Intangible Plant

301. Organization
302. Franchises and Consents
303. Other Intangible Plant

B. Source-of-Supply Plant

310. Land and Land Rights
311. Structures and Improvements
312. Collecting and Impounding Reservoirs
313. Lake, River, and Other Intakes
314. Wells and Springs
315. Infiltration Galleries and Tunnels
316. Supply Mains
317. Other Water Source Plant

C. Pumping Plant

320. Land and Land Rights
321. Structures and Improvements
322. Boiler Plant Equipment
323. Other Power Production Equipment
324. Steam Pumping Equipment
325. Electric Pumping Equipment
326. Diesel Pumping Equipment
327. Hydraulic Pumping Equipment
328. Other Pumping Equipment

D. Water Treatment Plant

330. Land and Land Rights
331. Structures and Improvements
332. Water Treatment Equipment

E. Transmission and Distribution Plant

340. Land and Land Rights
341. Structures and Improvements
342. Distribution Reservoirs and Standpipes
343. Transmission and Distribution Mains
344. Fire Mains
345. Services
346. Meters
347. Meter Installations
348. Hydrants
349. Other Transmission and Distribution Plant

F. General Plant

370. Land and Land Rights
371. Structures and Improvements
372. Office Furniture and Equipment
373. Transportation Equipment
374. Stores Equipment
375. Laboratory Equipment
376. Communication Equipment
377. Power-operated Equipment
378. Tools, Shop, and Garage Equipment
379. Other General Plant

APPENDIX D—List of Accounts Required of Water Utilities, by Classes

Operating Revenue Accounts

Accounts for Class D Utilities	Accounts for Class C Utilities	Accounts for Class A and B Utilities
	A. Sales of Water	
2501. Metered Sales to General Customers	1501. Metered Sales to General Customers	501. Metered Sales to General Customers
2502. Unmetered Sales to General Customers	1502. Unmetered Sales to General Customers	502. Unmetered Sales to General Customers
2503. Sales for Resale	1503. Sales for Resale	503. Sales for Resale
2504. Sales to Irrigation Customers	1504. Sales to Irrigation Customers	504. Sales to Irrigation Customers
2505. Municipal Fire Hydrant Rentals	1505. Municipal Fire Hydrant Rentals	505. Municipal Fire Hydrant Rentals
2506. Other Fire Protection Sales	1506. Other Fire Protection Sales	506. Other Fire Protection Sales
2507. Other Sales to Public Authorities	1507. Other Sales to Public Authorities	507. Other Sales to Public Authorities
2508. Interdepartmental Sales	1508. Interdepartmental Sales	508. Interdepartmental Sales
	B. Other Water Revenues	
2510. Forfeited Discounts	1510. Forfeited Discounts	510. Forfeited Discounts
2511. Miscellaneous Service Revenues	1511. Miscellaneous Service Revenues	511. Miscellaneous Service Revenues
2513. Rent From Water Property	1513. Rent From Water Property	513. Rent From Water Property
2514. Interdepartmental Rents	1514. Interdepartmental Rents	514. Interdepartmental Rents
2515. Other Water Revenues	1515. Other Water Revenues	515. Other Water Revenues

Operating Expense Accounts

	A. Source-of-Supply Expenses	
Operation	*Operation*	*Operation*
2701. Operation Labor and Expenses	1701. Operation Labor and Expenses	701. Operation Supervision and Engineering 702. Operation Labor and Expenses 703. Miscellaneous Expenses
	1704. Purchased Water	704. Purchased Water

APPENDIX D—*List of Accounts Required of Water Utilities, by Classes—Operating Expense Accounts (contd.)*

Accounts for Class D Utilities	Accounts for Class C Utilities	Accounts for Class A and B Utilities
A. Source-of-Supply Expenses (*contd.*)		
Maintenance	*Maintenance*	*Maintenance*
	(Include in Acct. No. 1706, 1707, or 1712, as appropriate)	←705. Maintenance Supervision and Engineering
	1706. Maintenance of Structures and Improvements	706. Maintenance of Structures and Improvements
	1707. Maintenance of Collecting and Impounding Reservoirs	707. Maintenance of Collecting and Impounding Reservoirs
2705. Maintenance of Structures and Equipment		708. Maintenance of Lake, River, and Other Intakes
		709. Maintenance of Wells and Springs
		710. Maintenance of Infiltration Galleries and Tunnels
		711. Maintenance of Supply Mains
	1712. Maintenance of Other Water Source Plant	712. Maintenance of Other Water Source Plant
Rent	*Rent*	*Rent*
2713. Rents	1713. Rents	713. Rents
B. Pumping Expenses		
Operation	*Operation*	*Operation*
	(Include in Acct. No. 1722 or 1724, as appropriate)	←720. Operation Supervision and Engineering
	1721. Fuel for Power Production	721. Fuel for Power Production
	1722. Power Production Labor and Expenses	722. Power Production Labor and Expenses
	1723. Fuel or Power Purchased for Pumping	723. Fuel or Power Purchased for Pumping
	1724. Pumping Labor and Expenses	724. Pumping Labor and Expenses
	1725. Miscellaneous Expenses	725. Miscellaneous Expenses
2720. Operation Labor and Expenses	1726. Expenses Transferred—*Credit*	726. Expenses Transferred—*Credit*

APPENDIX D—*List of Accounts Required of Water Utilities, by Classes—Operating Expense Accounts (contd.)*

Accounts for Class D Utilities	Accounts for Class C Utilities	Accounts for Class A and B Utilities
B. Pumping Expenses (*contd.*)		
Maintenance	*Maintenance*	*Maintenance*
	(Include in Acct. No. 1728, 1729, or 1730, as appropriate)	←727. Maintenance Supervision and Engineering
2727. Maintenance of Structures and Equipment	1728. Maintenance of Structures and Improvements	728. Maintenance of Structures and Improvements
	1729. Maintenance of Power Production Equipment	729. Maintenance of Power Production Equipment
	1730. Maintenance of Pumping Equipment	730. Maintenance of Pumping Equipment
Rent	*Rent*	*Rent*
2731. Rents	1731. Rents	731. Rents
C. Water Treatment Expenses		
Operation	*Operation*	*Operation*
	(Include in Acct. No. 1742)	←740. Operation Supervision and Engineering
2741. Operation Labor and Expenses	1741. Chemicals	741. Chemicals
	1742. Operation Labor and Expenses	742. Operation Labor and Expenses
		743. Miscellaneous Expenses
Maintenance	*Maintenance*	*Maintenance*
	(Include in Acct. No. 1745 or 1746, as appropriate)	←744. Maintenance Supervision and Engineering
2745. Maintenance of Structures and Equipment	1745. Maintenance of Structures and Improvements	745. Maintenance of Structures and Improvements
	1746. Maintenance of Water Treatment Equipment	746. Maintenance of Water Treatment Equipment
Rent	*Rent*	*Rent*
2747. Rents	1747. Rents	747. Rents

APPENDIX D—*List of Accounts Required of Water Utilities, by Classes—Operating Expense Accounts (contd.)*

Accounts for Class D Utilities	Accounts for Class C Utilities	Accounts for Class A and B Utilities
D. Transmission and Distribution Expenses		
Operation	*Operation*	*Operation*
2751. Operation Labor and Expenses	1751. Operation Labor and Expenses	750. Operation Supervision and Engineering 751. Storage Facilities Expenses 752. Transmission and Distribution Lines Expenses 753. Meter Expenses 754. Customer Installations Expenses 755. Miscellaneous Expenses
Maintenance	*Maintenance*	*Maintenance*
2757. Maintenance of Structures and Equipment	(Include in Acct. No. 1757, 1758, 1759, or 1761, as appropriate) 1757. Maintenance of Structures and Improvements 1758. Maintenance of Distribution Reservoirs and Standpipes 1759. Maintenance of Mains 1761. Maintenance of Other Transmission and Distribution System Facilities	←756. Maintenance Supervision and Engineering 757. Maintenance of Structures and Improvements 758. Maintenance of Distribution Reservoirs and Standpipes 759. Maintenance of Transmission and Distribution Mains 760. Maintenance of Fire Mains 761. Maintenance of Services 762. Maintenance of Meters 763. Maintenance of Hydrants 764. Maintenance of Miscellaneous Plant
Rent	*Rent*	*Rent*
2765. Rents	1765. Rents	765. Rents

APPENDIX D—*List of Accounts Required of Water Utilities, by Classes—Operating Expense Accounts (contd.)*

Accounts for Class D Utilities	Accounts for Class C Utilities	Accounts for Class A and B Utilities
E. Customer Accounts Expenses		
Operation	*Operation*	*Operation*
	(Include in Acct. No. 1773 or 1774, as appropriate)	←772. Supervision
	1773. Meter Reading Expenses	773. Meter Reading Expenses
1773. Operation Labor and Expenses	1774. Other Customer Accounts Expenses	774. Customer Records and Collection Expenses 775. Miscellaneous Customer Accounts Expenses
1776. Uncollectible Accounts	1776. Uncollectible Accounts	776. Uncollectible Accounts
F. Sales Expenses		
Operation	*Operation*	*Operation*
2779. Sales Promotion Expenses	1779. Sales Promotion Expenses	779. Supervision 780. Demonstrating and Selling Expenses 781. Advertising Expense 782. Miscellaneous Sales Expenses 783. Merchandising, Jobbing, and Contract Work

APPENDIX D—*List of Accounts Required of Water Utilities, by Classes—Operating Expense Accounts (contd.)*

Accounts for Class D Utilities	Accounts for Class C Utilities	Accounts for Class A and B Utilities
	G. Administrative and General Expenses	
Operation	*Operation*	*Operation*
2787. Administrative and General Salaries	1787. Administrative and General Salaries	787. Administrative and General Salaries
2788. Office Supplies and Other Expenses	1788. Office Supplies and Other Expenses	788. Office Supplies and Other Expenses
2789. Administrative Expenses Transferred—*Credit*	1789. Administrative Expenses Transferred—*Credit*	789. Administrative Expenses Transferred—*Credit*
2790. Outside Services Employed	1790. Outside Services Employed	790. Outside Services Employed
2791. Property Insurance	1791. Property Insurance	791. Property Insurance
2792. Injuries and Damages	1792. Injuries and Damages	792. Injuries and Damages
2793. Employees' Pensions and Benefits	1793. Employees' Pensions and Benefits	793. Employees' Pensions and Benefits
2794. Franchise Requirements	1794. Franchise Requirements	794. Franchise Requirements
2795. Regulatory Commission Expenses	1795. Regulatory Commission Expenses	795. Regulatory Commission Expenses
2796. Miscellaneous General Expenses	1796. Miscellaneous General Expenses	796. Miscellaneous General Expenses
2797. Duplicate Charges—*Credit*	1797. Duplicate Charges—*Credit*	797. Duplicate Charges—*Credit*
Maintenance	*Maintenance*	*Maintenance*
2800. Maintenance of General Plant	1800. Maintenance of General Plant	800. Maintenance of General Plant
Rent	*Rent*	*Rent*
2801. Rents	1801. Rents	801. Rents

Activation of Silica for Use in Water Treatment

By Charles A. Black

A paper presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by Charles A. Black, Pres., Black Labs., Inc., Gainesville, Fla.

ACTIVATED silica, although its application to water treatment is relatively new, actually has a long history. More than 150 years ago, Pott reported the preparation of a "semi-solution" of silica, but Graham is usually credited with the discovery of silica sol. Graham added water glass and weak hydrochloric acid to form silica sol as early as 1884. In the same year Nahnsen patented a process for water purification including treatment with lime, soluble salts of aluminum, and soluble silicates which had been neutralized with an acid. Later Parkin developed a process involving the addition of sodium silicate to a mine water to neutralize the acid. Martin, in 1935, acquired a patent for the use of an alkali metal salt in an impure water previously treated with an acidic material. These patents involve the formation of silica sols but evidently were never successfully applied on a large commercial scale. Smith, in 1924, recorded an attempt to use silica sols in water purification. The results were not encouraging, probably because the dosage was excessive.

The first successful efforts to use silica sols on a large scale in water treatment took place in 1936. The work was done independently and concurrently by J. R. Baylis at Chicago and by Graf and Schworm at St. Louis. Baylis showed that the addition of sulfuric acid to a dilute solution of sodium silicate, with proper aging, could improve the alum coagulation of Lake Michigan water appreciably. Graf and Schworm demonstrated, in both laboratory experiments and plant scale trials, that solutions of alum and sodium silicate of approximately equal concentrations could be used as an effective coagulant aid. It is surprising to note that, as early as 1884, Graham was so close to the views now considered modern. Graham has been generally credited with introducing the terms sol, gel, and peptization.

Definition of Terms

Because activated silica, although in limited use for a great many years, has not as yet been widely accepted throughout the country as a conventional coagulant or coagulant aid, some of the terms employed in this paper may not be familiar. Consequently, it has been deemed advisable to include the following definitions applicable to the theory of activated silica:

Activated silica. This term designates a negatively charged colloidal particle formed by the reaction of a dilute sodium silicate solution with a dilute solution of an acidic material or other activant.

Sol. This is a general term applied to colloidal dispersions as distinguished from true solutions.

Gel. A silica gel is a heavily hydrated, interlaced, fibrillar or brush heap structure of very large polysilicic acid molecules, with the spaces filled with water or dilute silicate solution.

Gel induction time. The time interval between the addition of the activant to the sodium silicate solution and the first determinable gel formation is the "gel induction time" (sometimes called "gel time").

Micelle. This term, taken from the French, has been construed to indicate an internal-phase particle that possesses a double layer of charges of opposite sign adjacent to the surface. As applied to activated silica, it usually refers to a particle size varying between 0.1 and 1.0 mμ.

Mole ratio. As applied to activated silica, this term refers to the ratio of the number of moles of activant to the number of moles of sodium oxide in the silicate.

Percentage neutralization. Taking a 1:1 mole ratio of activant to sodium oxide content as unity, or 100 per cent, this term expresses as a percentage the ratio of equivalents of activant to equivalents of sodium oxide content added in the neutralization process.

Parts per million activated silica (*$^-SiO_2^-$*). This term represents the parts per million available $^-SiO_2^-$ micelles present. These micelles have a negative charge and should not be confused with SiO_2 as normally found in water supplies.

Methods of Activation

Activated silica sol, prepared by the partial or total reaction of the sodium oxide content in sodium silicate, has often been applied successfully as a coagulant aid. The process involves the reaction of a suitable grade of sodium silicate, such as one having a ratio of 1 part Na_2O to 3.2 parts SiO_2. A typical analysis is: Na_2O, 8.9 per cent; SiO_2, 28.7 per cent; and H_2O, 62.4 per cent. The activation of sodium silicate with strong acids follows a pH curve similar to that for the reaction of a strong acid and strong base.

Probably the first activated silica sol successfully used as a coagulant aid in the treatment of raw water was developed by Baylis (*1*), working in Chicago on Lake Michigan water. He found that, when the alkalinity of sodium silicate was partially neutralized by sulfuric acid, it acted as a coagulant aid for this water. The Baylis process involved the addition of a diluted sodium silicate solution to a level of 1.5 per cent SiO_2 and the addition of sulfuric acid sufficient to neutralize approximately 85 per cent of the alkalinity. This solution was aged for 2 hr and then diluted to a level of 0.6 per cent SiO_2, producing a very efficient coagulant aid.

The Graf-Schworm process (*2*) involves the addition of 1 per cent alum solution to a 1 per cent silicate solution in a ratio of 4 parts of alum to 1 part of silicate. This mixture is then used immediately as a coagulant aid.

A method of activation developed by Hay (*3*) involved the use of ammonium salts. This method differed from both the Baylis and Graf-Schworm processes in that it did not involve alkalinity neutralization and the pH of the final silica sol was much higher than in either of the other methods. Hay also suggested the use of carbon dioxide, sulfur dioxide, sulfur trioxide, chlorine, and acid salts as activating agents, as well as the concept of continuous activation. The Hay process for activating silica is commonly called N-Sol A. The usual method of producing this sol is to mix

diluted silicate and ammonium sulfate solutions in equimolar proportions, to age this mixture at a concentration of 2 per cent SiO_2 for 1 hr, and then to dilute it below 1.3 per cent for storage to prevent gel formation. This sol has less tendency to gel and can be safely stored and used at approximately twice the safe storage concentration of the Baylis sol.

The Baker-Dedrick sol (*4*), commonly called N-Sol B, is produced by adding dilute solutions of sodium silicate to dilute solutions of a metal salt capable of forming an insoluble silicate. These solutions are mixed in equimolar proportions, aged, and added to the water treatment system or diluted to prevent gel formation.

Many other activants have been used to form activated silica sols, but the methods previously mentioned are the most important insofar as general acceptance and basic work are concerned. Silica sols made by the hydrolysis of silicon tetrachloride have only a slight effect on coagulation. Those prepared by the passage of a diluted soluble silicate through an ion-exchange resin have little, if any, coagulant activity.

Theory

The internal-phase fibers of a silicic acid gel are regarded by Hurd and Miller (*5*) as consisting of condensed silicic acid molecules that form long, branched chains profusely entangled. This condensation is produced by the splitting off of the water, starting at first by a reaction between simple molecules and continuing between the larger molecules thus formed until a network develops. The vast surface created by such a brush heap structure of combined silicic acid molecules can account for the adsorption of the water molecules and for their being held in a more or less rigid condition. According to Hurd and Miller, any condition that tends to alter the rate of reaction accordingly affects the rate of the setting of the gel. During the aging period, the low-molecular-weight polymer of silicic acid formed by the neutralization of the silicate alkalinity by acidic material increases in size. If the aging process is not stopped by dilution, addition of alkali, or other means, the mixture gels. By controlling the aging time, the size of the silica micelle can be varied over a wide range. During aging, the more soluble silica changes to a colloidal form that does not react with ammonium molybdate in the usual analytical test for silica.

Assuming that the gelation is due to a condensation reaction of this type, fastest gelling should occur near the pH of least ionization, where there is a minimum of repulsion forces between similarly charged silicic acids or hydroxides or an equal number of positively or negatively charged species containing silicon hydroxides. The occurrence of such a maximum rate of gelation at an initial pH of approximately 7 is evidence that the silicic acids are much stronger than is ordinarily supposed. The increase in pH during aging and gelation indicates that the polysilicic acids forming are weaker and are more extensively hydrolyzed. Published data (*6*) clearly show that the gelling power of ammonium salts is not due entirely to acid formed by hydrolysis, as they form gels at pH values only slightly less alkaline than the sodium silicates themselves. Systems of silicates with acids do not form gels at these pH values. The sodium aluminate–silicate mixtures have higher pH values than silicate solutions alone. The ability of ammonium salts to gel

sodium silicates is, therefore, probably due to the formation of slightly ionized, heavily hydrated, insoluble gelatinous salts.

The sodium silicoaluminate gels formed when sodium silicates and aluminates are mixed contain sodium ions that are not removable by extensive washing with water. These sodium ions are replaceable with other cations like calcium and magnesium. Such products, usually termed artificial zeolites, are used extensively in water treatment. Because aluminum or aluminate ions, as well as the silicates, can be regarded as polyfunctional, the formation of a silica alumina gel probably involves a copolymerization reaction.

Thus, it can be seen that there are at least four distinct methods of forming activated silica sols and silica gels: (1) alkalinity neutralization with acids or acid salts; (2) the use of ammonium sulfate to form slightly ionized, heavily hydrated gelatinous salts; (3) the use of sodium aluminate to form silicoaluminate sols; and (4) the addition of dilute solutions of a metal salt to sodium silicate to form insoluble salts.

In general, the rate of gelation of mixtures of 3.3-ratio sodium silicate with the various gelling agents increases in the following order: ammonium sulfate, sulfuric acid, hydrochloric acid, and sodium aluminate. Under certain conditions this order does not hold, however. The mole ratio of the gelling reagent to the alkali of the silicate does not affect the gel time as much with the aluminate and ammonium salts as it does with the acids.

The actual point of gel formation is usually determined by the loss of uniform fluid flow, the appearance of breakage planes when the mixture is tilted, and the adherence of solid gel to the glass wall of the container. The gel induction time obtained in this manner is reproducible within 2 per cent and usually corresponds fairly closely to the "time of set" determined by the "tilted-rod" method extensively used by Hurd and collaborators.

It has been found (*6*) that, for best results, the aging period for activated silica sols should range between 10 and 50 per cent of the actual time necessary for gel formation. Optimum results are usually obtained when the aging period is approximately 25 per cent of the gel induction time.

Carbon Dioxide and Chlorine Activation

The three methods of silica activation probably most widely used at present employ sulfuric acid, alum, or ammonium sulfate. At least two additional methods, developed in recent years, have shown considerable promise, however. One of these involves the neutralization of the alkalinity by the use of carbon dioxide. This method is of special interest where carbon dioxide is available from the burning of lime sludge in softening operations or as a constituent of burner gases. This activation process, utilizing gases from the exhaust of diesel engines containing 4–5 per cent carbon dioxide gas, is now being employed at Miami, Fla. (*7*). Activated silica is prepared in batch quantities, and approximately 30 mgd of water is being treated with approximately 2 ppm SiO_2.

Another process coming into wide favor at present utilizes gaseous chlorine for activation. This method of activation has many advantages. The hypochlorite produced in the reaction contains, in effect, the same oxidizing power as the original chlorine. Hence, none of the chlorine applied is lost, and

it is available for disinfection and oxidation of organic materials. Thus, the actual cost of chlorine as an activator is nothing, as it will replace an equivalent amount already used in the filter plant. The relatively low solubility of chlorine in water complicated the development of a continuous process for the production of this sol, but this difficulty has been overcome by at least two major chemical-feeder manufacturers. One of these feeders utilizes a high percentage of activation, a relatively high "SiO_2" content of the aging mixture, and a very low aging time. The solution to be used is prepared continuously and employed immediately after preparation.

Benefits of Activated Silica

The application of activated silica to water treatment has brought numerous benefits never before obtained with a coagulant aid. Baylis' study showed that, in Lake Michigan and synthetic waters, the sol decreased the time required to form a floc; increased its size, toughness, and density; permitted more rapid settling; produced a clearer settled and filtered water; and lengthened filter runs. The sol made it possible to use higher flow rates and coarser filter media and produced good water over a wider pH range. Magnesium could be removed at a lower pH by using the sol. If considerable magnesium was present, it could be coagulated by lime and silica alone.

The first successful plant scale use of activated silica sol employing ammonium sulfate was made in 1943 by Black (*8*) in a Florida plant. The addition of 4 ppm silica as "SiO_2" prior to feeding 85 ppm of lime and 8.5 ppm alum produced a larger, tougher, heavier floc that settled faster and resulted in increased color removal and clearer water. In this plant, the addition of 4 ppm silica replaced a dosage of 70 ppm alum as a coagulant with a very substantial financial saving. At approximately the same time Black also initiated the application of activated silica to a softening plant, using sulfuric acid as the activant. Since then activated silica has become a standard coagulant for lime softening in Florida, and, to some extent, has replaced alum. It is also used as a coagulant aid in the treatment of surface waters with alum. It gives a tougher, heavier, and faster settling floc than alum alone.

The benefits observed when activated silica has been used in raw-water coagulation are many, although all are not obtained in every instance. Often a saving in the cost of chemical treatment results from the reduction in the amount of alum or iron salts needed for good coagulation. Sometimes the saving stems from increasing the capacity of the equipment by creating a heavier floc, thus making the existing equipment serve at higher capacities and either postponing the necessity for expanding the plant or reducing the initial cost of new installations. Almost always activated silica in the proper proportion increases the speed of formation and the size, density, and strength of the floc.

It should not be assumed that, because silica is present in a raw water to the extent of 10–20 ppm, activated silica will not be beneficial. The natural and activated forms of silica differ, or at least produce different effects. Usually, adding activated silica to the raw water along with the other coagulants will actually decrease the silica content of the finished water, because more and better coagulation is obtained.

Activated silica has been demonstrated to be a very economical method of treatment. A recent installation in an eastern steel mill showed almost a 50 per cent reduction in water treating cost when activated silica sol treatment was started. Hazlip (*9*) stated that, at Houma, La., the use of activated silica and reductions in the amount of other chemicals fed decreased the cost from $41.41 to $20.72 per million gallons of water treated. The cost of silica sol application is estimated at 35–50 cents per part per million "SiO_2" for each million gallons of water treated.

Black (*10*) found activated silica highly effective when used in conjunction with the lime softening of Florida well waters. The process usually consists of softening with excess lime and using approximately 8.5 ppm alum as the coagulant. In some plants, the silica is substituted for all of the alum; in others, the addition of alum with the silica has been found desirable. With the silica treatment the floc particles are large and "leathery." Turbidities of settled waters are reduced greatly and the filter runs are lengthened. Black states that, although activated silica used in conjunction with another coagulant should properly be called a coagulant aid, the time has come to recognize that it may, and often does, act as a coagulant in the truest sense of the word.

Plant Applications

It is important to learn the optimum proportions of activated silica and other coagulants and the proper order of addition. These factors should be studied by means of jar tests, which, if carefully conducted, give a good indication of results to be expected in plant practice. The amount of activated silica usually required varies from 2 to 15 ppm. Excessive amounts of silica destroy the effectiveness of the alum, and no coagulation is obtained. The point of application of the silica is often a critical factor. In combination with alum, negative results are sometimes obtained when the silica is added ahead of the alum; whereas, when the silica is added immediately after the formation of a pinpoint floc, a large, heavy alum floc results. Very often, however, it is found that the silica should be added to the raw water ahead of the other chemicals. The optimum procedure must be determined by jar tests and plant trials.

The effect of temperature on the results obtained with activated silica was investigated by Spencer, Middleton, and Merrill (*11*). It was found that activated silica appreciably lessened the time necessary for floc formation at low temperatures. The use of activated silica at low temperatures also greatly decreased the problem of after-precipitation of alum.

Effect on Filter Runs

It has been reported by several persons that activated silica has decreased filter runs. Upon investigation by the individuals concerned, it was found that a sticky, gelatinous film had formed on the top of the filter, thus plugging it. Several explanations for this phenomenon have been found. If only part of the sodium alkalinity is neutralized, the floc formed may be sticky and could, under unfavorable circumstances, cause filter plugging. No difficulty of this type is encountered with ammonium alkalinity. Filter plugging occurring when Baylis sol of 85 per cent neutralization was used disappeared when the silicate was 95

per cent neutralized with sulfuric acid or 100 per cent activated with ammonium sulfate. A change in the alum-silica ratio or in the relative points of application of alum and silica may also eliminate filter plugging.

In one installation, it was found that the proportion of mud and floc indicated that backwash was decidedly inadequate. Surface wash units were installed in the filter beds. With the efficient surface wash, a negligible amount of dirt remained after backwashing, and filter plugging was entirely eliminated. Because a certain quantity of floc is carried to the average filter bed from the sedimentation basin, the application of silica is warranted only if it is known that an efficient backwash is possible. If the silica-alum floc, which is dense and slightly sticky, cannot be washed properly from the bed, it accumulates in serious proportions, increasing the frequency of backwash to a point at which operation becomes very difficult. This problem is especially likely to arise if the filter beds are dirty before the application of silica.

Conclusions

Activated silica sols are truly a welcome addition to the family of chemicals available for water treatment. When properly applied in correct dosages activated silica will almost always improve the coagulation and chemical quality of the water treated. Activated silica, like all other chemicals used in water treatment, must, however, be properly applied or its beneficial effects cannot be realized. It is the opinion of the author that future applications of activated silica in this country will be numerous and that the trend will be toward continuous activation with carbon dioxide and chlorine.

References

1. Baylis, J. R. Silicates as Aids to Coagulation. *Jour. AWWA*, **29**:1355 (Sept. 1937).
2. Graf, A. V. & Schworm, W. B. Solution Mixture of Sodium Silicates Improves Coagulation. *W.W. Eng.*, **90**: 1514 (1937).
3. Hay, H. R. Water Purification Methods Involving Sodium Silicates. *Jour. AWWA*, **36**:626 (June 1944).
4. Baker, C. L. & Dedrick, C. H. U.S. Patent 2,310,009 (Feb. 2, 1943).
5. Hurd, C. B. & Miller, P. S. Studies on Silicic Acid Gels. II. The Time of Set as a Function of the Temperature. *J. Physical Chem.*, **36**:2194 (1932).
6. Bul. 52–19, Philadelphia Quartz Co., Philadelphia.
7. Henry, C. R. Characteristics of Activated Silica Sols. *Jour. AWWA*, **41**: 551 (June 1949).
8. Black, A. P. *Proc. 5th Ann. Wtr. Conf. Eng. Soc. Western Pa.*, p. 170 (1944).
9. Hazlip, S. W. Use of Activated Sodium Silicate at Municipal Water Plant, Houma, La. *La. Eng. Expt. Sta. Bul.*, No. 10, p. 59 (1947).
10. Black, A. P. Personal communication.
11. Spencer, R. W.; Middleton, A. B.; & Merrill, R. C. Gelation Times of Varous Silica Sols. *Ind. Eng. Chem.*, **43**:1129 (1951).

Discussion

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The author has outlined the uses and characteristics of activated silica and has shown that many reactants can be employed. He has indicated that heretofore activated silica has been prepared largely by the batch method and has pointed out that continuous methods are desirable but not as yet

widely accepted. It is the purpose of this discussion to describe how chlorine is used in the continuous activation of silica.

For several years this method has been employed on a batch basis in paper making and in the clarification of domestic water, with makeshift activation units. Klinger (*1*) and others who have investigated the applicability of chlorine-activated silica have found it to compare very favorably with earlier methods. Chlorine-activated silica is especially attractive because all the chlorine used for activation is available in full strength to perform the normal functions of chlorine. This means that every pound of chlorine used in activation can be subtracted from the normal prechlorine dosage. In plants where prechlorination has not been practiced, this silica activation process will yield all the benefits of prechlorination in addition to its primary function of activation, and, if the chlorine demand of the raw water is not too high, there will be a good chance that postchlorination can be reduced to some degree.

The activation of silica with chlorine differs from other methods in several respects: the aging time has been greatly shortened, the silicate is pumped full strength, and the process is continuous. The procedure is relatively simple because it entails the control of only three ingredients—chlorine, water, and sodium silicate. As in other methods, the sodium silicate is diluted and the alkali is partially or wholly neutralized. This neutralized solution is then aged, further diluted, and fed to the point of use.

Description of Equipment

In equipment developed for this process,* the dilution water and chlorine are conducted into a reaction chamber where the sodium silicate is diluted to the proper point and the chlorine neutralizes the alkali to the proper degree. Aging takes place in the same chamber. The finished product is removed by an ejector system, which, in some ways, is the heart of the process. In addition to removing and transporting the finished product to the point of use, the ejector also creates the vacuum needed to meter the flow of chlorine, pulls in the air used in mixing, and provides the necessary final dilution water for stabilizing the finished solution.

The finished solution contains, in addition to silica micelles ($^{-}SiO_2^{-}$), all of the chlorine used in the neutralization of the alkali. The process may be expressed as an equation:

$$Na_2O \cdot SiO_2 + HOCl + HCl \rightarrow {}^{-}SiO_2^{-} + NaOCl + NaCl + H_2O.$$

It will be noted that the $^{-}SiO_2^{-}$ does not enter into reaction with chlorine but is simply released from captivity, as it were. The oxidizing power of the chlorine used remains, in the form of sodium hypochlorite (NaOCl). This provides the basis for the previous statement that all the chlorine used is available for the normal functions of that chemical. The pH of the solution delivered to the point of application ranges from approximately 7.0 to 8.5.

Operation is simple. Chlorine, water, and sodium silicate feeds are set in accordance with a chart showing the

* The equipment described is the "WT Silactor," a product of Wallace and Tiernan Co., Newark, N.J.

amount of each required to produce the proper grade of activated silica. Chlorine feed is calibrated in pounds per 24 hours, water in gallons per minute, and sodium silicate in gallons per day.

This system works very close to the minimum sol life of the activated silica. When $^{-}SiO_2^{-}$ is released, the time required for it to form a gel will depend upon the initial dilution and the degree of activation. Thus, in the activation of silica, the sol life or gel time is controlled. In batch treatment, the sol is usually aged several hours and then diluted to a working strength of approximately 0.5 per cent. In the system under discussion, the sol life is relatively short—minutes instead of hours—and can be controlled. The sol is made and used within a matter of minutes, thereby decreasing the need for holding tanks and greatly simplifying the operation.

Good results in the preparation of activated silica depend to a considerable degree on proper initial mixing. The air used for this purpose in the continuous chlorine method is drawn into the reaction chamber by the vacuum created by the ejector. Entering at the bottom of the chamber, the air bubbles upward against the downward flow of silicate and water. The appearance of a bluish color or haze is evidence of properly activated silica.

Difficulties due to uncontrolled gelation at unpredictable times have been completely eliminated in this system. The only place where any gel can accumulate is the reaction chamber, from which it can be removed easily by loosening two wing nuts, thus releasing the entire jar. A rub of the hand on the inside removes all gel, and, after replacement of the jar, the equipment is again ready to run. The whole operation seldom requires more than a few minutes.

The ejector which removes the activated silica from the reaction jar and provides a vacuum for the operation of the whole system is of such size that the water used produces a final dilution of approximately 0.5 per cent. This final dilution inhibits further micelle growths, so that the product can then be transported any reasonable distance without danger of gel formation. This is equivalent to the final dilution in the batch method that constitutes the working solution.

This system has passed through the field experimental stage. Units are now in operation on a great variety of waters and purification systems. Where the use of activated silica is justified, the chlorine activation process is proving as efficacious as other methods of activation, and the unit has demonstrated its reliability.

Reference

1. KLINGER, L. L. Improvements in the Coagulation of Surface Waters With Activated Silica. *Paper Trade J.*, **122**:15:44 (Apr. 11, 1946).

Critical Factors in Fluoride Distillation Technique

By Stephen Megregian and Ira Solet

A contribution to the Journal by Stephen Megregian, Sanitarian (R), and Ira Solet, Chemist, both of Div. of Dental Public Health, U.S. Public Health Service, Washington, D.C.

THE widespread adoption of water fluoridation has emphasized the need for rapid and accurate fluoride analysis. Although most potable waters can be analyzed for fluoride by colorimetric methods directly, interfering substances occasionally make this procedure inaccurate. The fluoride ion is quantitatively separated from most interferences by the Willard and Winter distillation technique. This method has withstood the test of time, and its various modifications are based on the needs of laboratories concerned with fluoride analysis. The present investigation was undertaken to determine those conditions which are critical and those which are superfluous to the rapid and quantitative recovery of fluoride from water samples.

The technique of fluoride distillation has been little changed since Willard and Winter (*1*) reported it in 1933. Dahle and Wickman (*2*) studied the procedure with respect to size of distilling flask, amount of nonvolatile acid used, amount of distillate collected, temperature of distillation, and presence of interferences. They concluded that a minimum of flask volume and acid volume, coupled with the highest practical distillation temperature (145°C with sulfuric acid), provided the best fluoride recovery. They also indicated that 90 per cent of the fluoride was recovered in the first 50 ml of distillate but that 100 ml was necessary to approach 100 per cent recovery. They showed that aluminum ion concentration is critical when more than 80 mg of Al^{+++} is present in the sample.

Gilkey and others (*3*) described a modified distillation apparatus containing tetrachloroethane in an outer jacket to control the distillation temperature at 146°C. They substituted steam in place of distilled water added through a capillary, claiming that this change reduced bumping during the distillation. Thrun (*4*) distilled water samples in approximately 15 min by passing compressed air rapidly through a distillation apparatus heated by a large flame, with conditions so adjusted that no temperature control was necessary during distillation. He reported no appreciable blank or significant loss of fluoride in the concentrations encountered in potable waters.

The distillation technique recommended in the 1946 edition of *Standard Methods* (*5*) will produce quantitative results, but it requires approximately 2 hr for the concentration and complete separation of fluoride from the water sample, with constant attendance during that time.

Experimental Apparatus

Three types of distillation apparatus were investigated. These were chosen as representing typical setups that

could be assembled in most water analysis laboratories. Apparatus A (Fig. 1) was purchased complete, except for a short extension that had to be welded on the steam inlet tube in order to submerge the tip in the acid. Apparatus B (Fig. 1) was made up from common laboratory glassware. It was felt that the use of a 300-ml short-neck Kjeldahl flask in place of a regular distilling flask is advantageous because the longer neck reduces contamination of the distillate by acid spray.

The diameter and shape of the discharge tube from the Kjeldahl flask is critical. Vapors and acid spray condensing in small-diameter tubing will form momentary liquid seals across the tube, and these will be carried into the distillate by the steam passing through, causing high blanks. Therefore, this tube should have a minimum inside diameter of 8 mm, and the tip protruding into the flask should be cut at an angle, thus permitting drops of spray to return to the flask. The tube should be at least 6 in. long and should connect to the condenser at an angle of approximately 30 deg above horizontal. In the third type of apparatus, the steam inlet tube was replaced by a separatory funnel, the stem of which was drawn out to a capillary and extended below the surface of the liquid in the flask. This setup was quickly abandoned because it was difficult to operate it at 5 ml per minute distillation rates without obtaining high blanks.

Sulfuric acid, diluted 1:1 with distilled water, was used in all of the experiments described. The fluorides were determined by the Megregian and Maier (*6*) photometric technique, using a Beckman Model B Spectro-

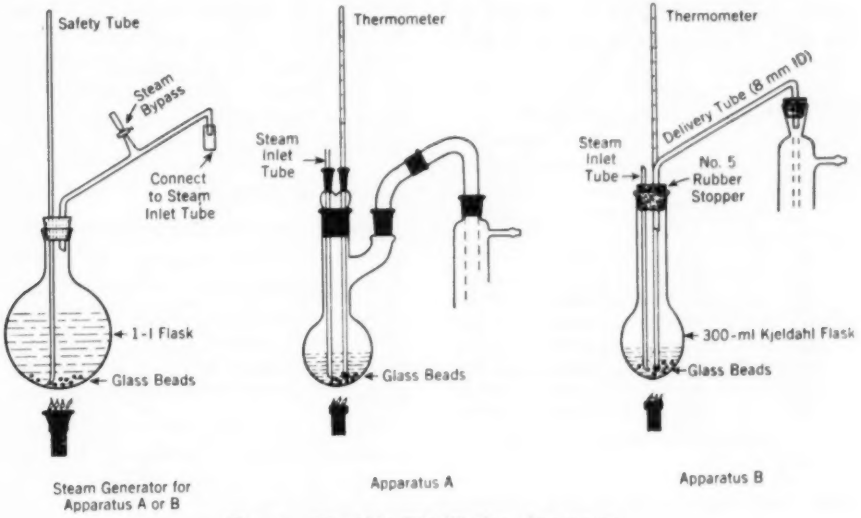

Fig. 1. Fluoride Distillation Apparatus

Apparatus A was purchased complete (except for a short extension to the steam inlet tube), while Apparatus B was made up from common laboratory glassware.

photometer * and 5.00-cm cuvettes for most of the analyses.

Blanks

Approximately 30 ml of 1 : 1 H_2SO_4 was added to 50 ml of fluoride-free distilled water in the distilling flask and mixed well. The apparatus was assembled and the distillation carried out as will be described. Fifty-milliliter portions of distillate were collected and analyzed for fluoride. The temperature of the distillation was held between 140°C and 155°C, except for the first 50 ml, and the rate of distillation was varied up to the point at which the condensate emerged hot from the condenser. The recoveries are shown in Table 1.

TABLE 1

Distillation of Fluoride Blanks

50-ml Samples	Distillation Rate *ml/min*	F Recovered as Blank	
		mg	*ppm*
1st	8.3	−0.0002	−0.004
2nd	8.7	−0.0011	−0.022
3rd	12.5*	−0.0003	−0.006
4th	12.5*	+0.0005	+0.010
5th	13.3*	−0.0019	−0.038
6th	8.7	+0.0005	+0.010
7th	8.3	+0.0008	+0.016
8th	3.4	−0.0002	−0.004

* Condensate hot.

The standard deviation, s, of the Megregian and Maier (*6*) method, as determined on a series of fifteen fluoride-free distilled water samples is ± 0.0008 mg. All but one of the recoveries listed in Table 1 fall within the $2s$ value of 0.0016 mg, the statistical value below which 95 per cent of the samples are expected to fall. Thus, the variations are no greater than those encountered by the analytical method employed, and it is safe to distill samples up to a rate of 10.0 ml per minute without appreciable sulfate error.

Temperature of Distillation

Figure 2 is composited from four replicate runs at each of the indicated temperatures and shows the cumulative recovery of 0.050 mg fluoride in 50 ml distilled water added to 30 ml 1 : 1 H_2SO_4; the distillate was collected and analyzed in 50-ml portions. These curves indicate that quantitative recovery is possible within a temperature range of 130°–150°C and with a total distillate volume of 150 ml.

Volume of Distillate

In order to determine the minimum distillate volume necessary to recover fluoride quantitatively, increasing quantities of fluoride in 50 ml of distilled water were added to 30 ml of 1 : 1 H_2SO_4 and distilled at a temperature of 140°C ± 5°C. The distillates were collected in 50-ml portions and analyzed as before. Figure 3 illustrates the results of this series of experiments. It is apparent from these curves that 150 ml of distillate is necessary for complete recovery within the range of fluoride quantities taken. Because, under the conditions of distillation, the first 50-ml portions are collected as the temperature of the samples is approaching 140°C, it is necessary that at least 100 ml of distillate be collected at the optimum temperature to insure quantitative recovery.

Rate of Distillation

Quantitative recovery of fluoride was obtained at distillation rates up to

* A product of Beckman Instruments, Inc., South Pasadena, Calif.

10.0 ml per minute with the apparatus mentioned and using the procedure to be described. Rates above this value could not be conveniently maintained because the pressure that developed in the steam generator occasionally blew out water through the safety tube, extinguishing the burner underneath and interrupting the continuity of the distillation. Quantitative recovery was also obtained at rates as low as 1.5 ml per minute.

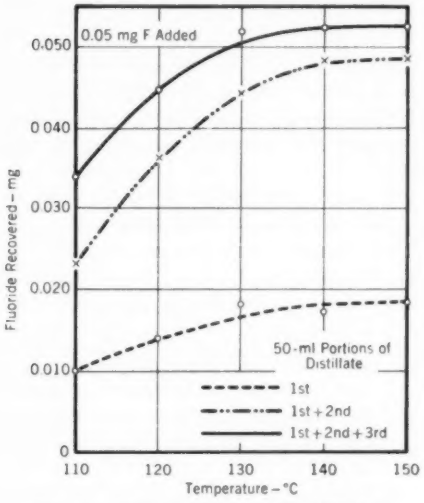

Fig. 2. Temperature of Distillation

Quantitative recovery is shown to be possible in the temperature range 130°–150°C, with a total distillate volume of 150 ml. The distillation rate was 5–10 ml per minute.

Interferences

Dahle and Wickman (*2*) and Willard and Winter (*1*) have determined the amounts of the various ions which affect fluoride recovery. Their work indicates that 80 mg of Al^{+++} or 100 mg of SiO_2 will prevent complete recovery. Other ions, such as Fe^{+++} and PO_4^{---}, which are common interferences in the subsequent determination do not affect quantitative recovery. Chloride is eliminated by precipitation as the silver salt.

The effects of aluminum and chloride were reinvestigated. Up to 20 mg of Al^{+++} ion in 50 ml water containing 0.1 mg F^- did not prevent quantitative recovery when 150 ml of distillate was collected in accordance with the recommended procedure.

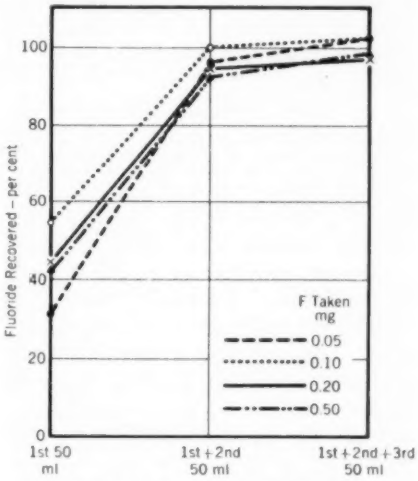

Fig. 3. Volume of Distillate

The sample volume was 50 ml and the distillation rate 5–10 ml per minute at a temperature of 140°C ± 5°C.

To study the effect of chloride, measured amounts of it were added to 50-ml samples containing 0.1 mg F^-, and 150 ml of distillate was collected and analyzed as before. The results are tabulated in Table 2.

The data presented emphasize the need for precipitation of chloride with silver sulfate during distillation. The

effect noted above on the zirconium-alizarin reagent for fluoride is, however, in a direction opposite to that produced by chloride ions when added as NaCl to unbuffered distilled water. Since the chloride ions added in the test distill over as HCl, the effect noted must be due to the H^+ ions accompanying the chloride. As this effect will occur with all the zirconium-alizarin reagents currently in use by water analysis laboratories, it is imperative that chlorides in excess of 5 mg be precipitated.

One other potential source of interference was investigated. It is expected that, if a significant quantity of organic matter is present in water samples, some of it may volatilize sufficiently during distillation to cause subsequent interference in the fluoride determination. Therefore, the analyst responsible for accurate fluoride analysis of unknown waters should observe the contents of the distilling flask for evidence of charring or excessive foaming and for unusual odors in the distillate, all of which are signs of possible organic interference with the subsequent fluoride determination. As an example, the interference caused by one of the common wetting agents, sodium alkyl aryl sulfonate,* is noted. Five milligrams of the detergent was added to 50 ml of water containing 0.10 mg of fluoride, and the sample was distilled by the recommended procedure. The analysis showed a loss of 0.025 mg F^-. Such concentrations may be extremely rare in water; however, when evidence of organic matter is present, the analyst must resort to complete alkaline evaporation and ashing of the residue before attempting to separate the fluoride from interferences.

* Marketed under the trade name, "Nacconol NR," by Allied Chemical and Dye Corp., New York.

Procedure for Distillation

The precision of the method of fluoride analysis to be used by the analyst and the accuracy required of the final result should be the basis for selecting the volume of sample necessary for distillation.

The standard deviation, *s*, of the Megregian and Maier photometric method has been given as ± 0.0008 mg in a 50-ml sample. If 150 ml of distillate are collected from the 50-ml sample, the resultant precision of the combined distillation and fluoride determination becomes ± 0.0024 mg or ± 0.05 ppm. Consequently, a 50-ml sample containing 1.0 ppm F can be determined, without concentration, with a resultant accuracy of ± 0.05 ppm. If greater accuracy is required or if the original sample is very low in fluoride content, it is recommended that a larger sample volume be taken and concentrated prior to distillation. If a sample size greater than 50 ml is necessary, it should be evaporated down to approximately 30 ml under alkaline conditions and transferred to the distilling flask with careful polic-

TABLE 2

Chloride Interference

Cl Added*		F Recovered	Cl Effect as F
mg	*ppm*	*mg*	*mg*
10	200	0.1021	0.0021
25	500	0.1034	0.0034
50	1,000	0.1112	0.0112
100	2,000	0.1224	0.0224
300	6,000	0.1439	0.0439

* To 50 ml H_2O containing 0.100 mg F.

ing. The transfer is completed by washing the sides of the container with 5–10-ml portions of fluoride-free distilled water. The total volume of sample plus wash water should not exceed 50 ml.

After the sample has been added, 8–10 glass beads, 30–40 ml of 1 : 1 H_2SO_4, and sufficient solid silver sulfate are added to react with the chloride present. The contents are mixed well and the flask is closed with the stopper containing the steam inlet tube, thermometer, and outlet tube. The outlet tube is attached to the condenser and a receiver is placed under the condenser to collect the condensate. Heat is applied to the distilling flask and the steam generator. The flame under the flask is regulated to permit rapid distillation but should be confined to the surface of the flask in contact with liquid. When the temperature reaches 130°C, steam is introduced into the flask by closing the bypass, and the temperature is held at 140°C ± 5°C during the course of the distillation. At least 100 ml of distillate should be collected with the temperature at the optimum range. This is readily accomplished under the conditions described, but, if the analyst desires to distill a sample larger than 50 ml without prior evaporation, he should compensate for the increased sample volume by collecting an equivalent volume of distillate in excess of 150 ml. A normal distillation under the above conditions can be completed in 20–30 min. Distillation rates up to 10 ml per minute can be easily maintained in the temperature range specified. The sulfuric acid residue can be reused for subsequent distillations if the accumulation of interfering ions does not exceed the limits noted. It is recommended that a blank run be made on all new setups before a distillation is attempted.

Other Considerations

The use of perchloric acid in the distilling flask in place of sulfuric acid should be avoided unless the analyst intends to complete the analysis by one of the thorium titration methods. Also, the presence of organic matter in unknown water samples is a potential hazard when perchloric acid is used, as it has been known to explode violently under such conditions. When using sulfuric acid, the quantity of sulfate that distills over at optimum temperature is too small to interfere with the usual zirconium-alizarin colorimetric methods.

It is evident that the physical conditions necessary for rapid and quantitative distillation of fluoride are quite broad. The optimum temperature range can be easily maintained, a minimum distillate volume associated with complete recovery has been established, and the rate of distillation has been shown to have a wide range. The amounts of aluminum or gelatinous silica that would retard the distillation are far greater than those normally encountered in potable waters, and chloride can readily be precipitated. Some waters may, however, contain a significant quantity of other volatile anions such as NO_2^- and NO_3^-, which would contribute acidity * to the distillate. If this quantity is suspected, an aliquot of the distillate can be titrated for acidity with 0.1*N* NaOH and the distillate neutralized

* Two hundred parts per million acidity as $CaCO_3$ in the distillate aliquot is equivalent to 0.10 ppm fluoride.

with 1.0*N* NaOH prior to the addition of fluoride reagents.

It is not necessary to protect the sides of the flask with asbestos as recommended in *Standard Methods,* provided reasonable care is exercised to prevent the open flame from continually coming into contact with the sides of the flask above the level of the liquid within. The rate of distillation of the first 50 ml is much faster without the asbestos.

One very important source of error in performing these distillations is the presence of leaks at the various joints and connections of the apparatus. Several experiments had to be repeated because as much as 10 per cent of the fluoride was lost through unnoticed loose connections.

Summary

It has been shown that fluoride can be distilled quantitatively from water samples, using common, inexpensive laboratory apparatus. The optimum temperature range for distillation has been determined to be 130°–150°C. Distillation rates between 5.0 and 10.0 ml per minute are practical, and it is necessary to collect at least 100 ml of the distillate at the optimum temperature for quantitative recovery. Interferences that may be present in water supplies were investigated and evaluated. The apparatus requirements and a recommended procedure have been presented.

References

1. Willard, H. H. & Winter, O. B. Volumetric Method for the Determination of Fluorine. *Anal. Chem.,* **5**:7 (1933).
2. Dahle, D. & Wickman, H. J. A Quantitative Study of Fluorine Distillation. *J. Assn. Off. Agr. Chem.,* **19**:313 (1936).
3. Gilkey, W. K.; Rohs, H. L.; & Hansen, H. V. Improved Apparatus for Isolation of Fluorine. *Anal. Chem.,* **8**:150 (1936).
4. Thrun, W. E. Rapid Methods for Determining Fluoride in Waters. *Anal. Chem.,* **22**:918 (1950).
5. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).
6. Megregian, S. & Maier, F. J. Modified Zirconium-Alizarin Reagent for Determination of Fluoride in Water. *Jour. AWWA,* **44**:239 (Mar. 1952).

AWWA B300-53T

American Water Works Association

Tentative
Standard Specifications
for
HYPOCHLORITES

These "Specifications for Hypochlorites" are based upon the best known experience and are intended for use under normal conditions. They are not designed for use under all conditions and the advisability of use of the material herein specified in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved as "Tentative" June 2, 1953

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AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

Tentative Standard Specifications for

Hypochlorites

Part A—Material Specifications

Sec. 1A—Scope

These specifications cover both calcium and sodium hypochlorites for use in the treatment of municipal and industrial water supplies. The specifications are intended for use in connection with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definitions

2A.1. *Chlorinated lime* (bleaching powder, chloride of lime) is a fine, yellowish-white deliquescent powder containing from 25 to 37 per cent available chlorine by weight. It is manufactured by the action of chlorine on selected slaked lime. The material contains some free lime. The exact formula is a matter of controversy. One of the more generally accepted formulas is $CaO \cdot 2CaOCl_2 \cdot 3H_2O$.

2A.2. *Calcium hypochlorite*, $Ca(OCl)_2$, is a white or yellowish-white powder, granular powder, or small pellet containing approximately 70 per cent available chlorine by weight. It may be manufactured by adding chlorine to a sodium hydroxide–hydrated lime slurry under carefully controlled conditions.

2A.3. *Sodium hypochlorite*, NaOCl, is a clear, light-yellow liquid containing up to 15 per cent available chlorine by volume. One method of manufacture is by passing chlorine into a caustic soda solution.

2A.4. *Available chlorine* is a term used to express the oxidizing power of the chlorine contained in the compounds described in this document. Available chlorine can be expressed in either one of two ways: (a) per cent by volume (trade per cent); or (b) per cent by weight. The basic formulas are:

$$\text{Volume or trade per cent} = \frac{\text{grams available chlorine per liter}}{10}$$

$$\text{Weight per cent} = \frac{\text{volume per cent}}{\text{sp gr of solution}}$$

Sec. 3A—Caution

Light and heat and organic matter accelerate the decomposition of hypochlorites. Dampness appreciably decreases the life of metal containers in which the powdered forms are shipped. Hypochlorites should be stored in a cool, dry place, preferably in the dark. Hypochlorites are very active chemically and should be stored so that it is not possible for them to come in contact with other material that is flammable, such as oil, grease, glycerine, or printed matter. When removing hypochlorite from a drum, never use a scoop or vessel contaminated with organic matter.

Sec. 4A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 5A—Methods of Testing

The laboratory examination shall be carried on in accordance with Part C (Testing Methods) of this document.

Sec. 6A—Impurities

The hypochlorite supplied under these specifications shall contain no soluble mineral or organic substances in quantities that would be deleterious or injurious to those consuming any water which is treated with hypochlorite within the acceptable limits.

Sec. 7A—Rejection

7A.1. Notice of dissatisfaction with a shipment, based on these specifications, must be in the hands of the consignor within 10 days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of receipt of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples taken as described in Part B. In the event that the results obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis, to a laboratory agreed upon by both parties. The results obtained by the referee shall be accepted as final, and the cost of the referee analysis shall be paid by the party whose results show the greatest discrepancy from the referee analysis.

7A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 8A—Physical Requirements

8A.1. Both chlorinated lime and calcium hypochlorite shall be substantially free from lumps. They shall not contain any dirt or other foreign material.

8A.2. The sodium hypochlorite solution shall be clear.

Sec. 9A—Available Chlorine

9A.1. Chlorinated lime shall contain not less than 25 per cent available chlorine by weight.

9A.2. Calcium hypochlorite shall contain not less than 70 per cent available chlorine by weight when shipped. The product shall be considered reasonably stable if the rate of loss of available chlorine is not in excess of 10 per cent during a year of storage.

9A.3. Sodium hypochlorite shall contain not less than 10 per cent available chlorine by volume (trade per cent—see Sec. 2A.4).

NOTE: If agreed upon by the parties concerned at the time of bid and purchase, a hypochlorite of a lower or higher available chlorine content than indicated above may be accepted. To be acceptable, samples should be taken at time of delivery (see Sec. 2C.4). Owing to the nature of the material, there may be some loss between the time of manufacture and the time that the material is analyzed by the purchaser.

Sec. 10A—Insoluble Matter

The insoluble matter in sodium hypochlorite shall not exceed 0.15 per cent by weight.

Sec. 11A—Free Alkali

The total free alkali (as NaOH) in sodium hypochlorite shall not exceed 1.5 per cent by weight.

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing, and marking of hypochlorites are intended for use with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. Five per cent of the packages or containers shall be sampled. No sample shall be taken from a broken package or container.

2B.3. The solid forms of hypochlorite may be sampled by means of a sampling tube which is at least $\frac{3}{4}$ in. in diameter.

2B.4. The gross sample of the solid forms of hypochlorite, weighing at least 16 lb, shall be mixed thoroughly and quartered to provide three 1-lb samples. This should be done rapidly and carefully to avoid loss of chlorine, and an ASTM sample splitter such as is used for sand or coal is recommended. The samples shall be sealed in airtight, moistureproof glass containers. Each sample shall be labeled to identify it, and the label shall be signed by the sampler.

2B.5. Sodium hypochlorite containers shall be mixed thoroughly by rolling or other suitable means before sampling. The gross sample, collected in a clean earthenware or glass container, shall contain at least 10 qt. The gross sample shall be mixed thoroughly and three 1-pint samples provided. These shall be sealed in airtight, moistureproof glass containers. Each sample container shall be labeled to identify it, and the label shall be signed by the sampler.

Sec. 3B—Packing and Shipping

3B.1. Packaging and shipping of all hypochlorites shall conform to the current regulations of the Interstate Commerce Commission, but, being subject to frequent changes, these should not be included in specifications for any order.

3B.2. Chlorinated lime may be shipped in 100- or 300-lb sheet-iron drums. The containers should be tight enough to hold the material without sifting, but not airtight, as this may cause a high pressure to develop in the drum should rapid decomposition of the bleaching powder occur. Sealing compound must not be used at the seams of metal drums.

3B.3. Calcium hypochlorite may be shipped in 5-lb cans and up to 100-lb metal drums. Sealing compound must not be used at the seams of the drums.

3B.4. Sodium hypochlorite solutions may be shipped in 2.5–13-gal glass carboys or approved plastic containers, or in 50-gal rubber-lined drums.

3B.5. The net weight of the packages or the net volume of the containers shall not be less than the recorded weight or volume nor more than 10 per cent greater. If exception is taken to the weight or volume of the material received, it shall be based on the certified unit weight or volume of not less than 10 per cent of the packages or containers selected at random from the entire shipment.

Sec. 4B—Marking

Each shipment shall carry with it clear identification of the material. Each container of 5 lb or less must be labeled "poison," and an antidote must be printed on the label. Each unit

package shall bear a yellow or white warning label as specified in the ICC regulations and shall have marked legibly thereon the percentage of available chlorine, the net weight of the contents, the name of the manufacturer, the lot number, and the brand name, if any.* The package may bear also the statement: "Guaranteed by (name of manufacturer) to meet the specifications of the American Water Works Association for hypochlorites."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of hypochlorites are intended for use in connection with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Sampling

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

2C.2. The samples of chlorinated lime and calcium hypochlorite shall be quartered carefully and rapidly to approximately 100 g. After thorough mixing, the sample shall be stored in an airtight glass container. The sample shall be kept in a dark, cool, dry place and the container kept closed except when portions are being weighed from it. This will avoid loss of available chlorine.

2C.3. Sodium hypochlorite solution shall be mixed thoroughly before withdrawing a portion for analysis. The sample bottle shall be stored in a dark, cool, dry place and kept perfectly sealed after the sample is withdrawn.

2C.4. The laboratory examination of the sample shall be completed within 5 working days after receipt of the shipment.

2C.5. Samples shall be stored at least 30 days from the date of receipt before disposing of them.

Sec. 3C—Available Chlorine

3C.1—Chlorinated Lime and Calcium Hypochlorite

3C.1.1—*Reagents:*

(a) Crystalline potassium iodide
(b) 0.1*N* sodium thiosulfate
(c) Glacial acetic acid
(d) Starch indicator.

3C.1.2—*Procedure:*

3C.1.2.1. Place approximately 7 g of chlorinated lime or calcium hypochlorite in a nonmetallic mortar, moisten with water, and grind until the particles are impalpable. Transfer to a 1-liter flask. Rinse the mortar with distilled water and make up to 1 liter.

3C.1.2.2. Measure 25 ml of the solution from the 1-liter flask into a 250-ml Erlenmeyer flask, add approximately 1 g of crystalline potassium iodide, and make acid with approximately 4 ml of glacial acetic acid. Titrate with 0.1*N* sodium thiosulfate, using starch as an indicator near the endpoint.

3C.1.3—*Calculation:*

$$\text{ml } 0.1N \text{ sodium thiosulfate} \times \frac{40 \times 0.003546 \times 100}{\text{weight of sample}} = \text{per cent available chlorine by weight}$$

3C.2—Sodium Hypochlorite

3C.2.1—*Reagents:*

(a) Crystalline potassium iodide
(b) 0.1*N* sodium thiosulfate

* The Interstate Commerce Commission yellow label is required for shipping containers of dry hypochlorites containing more than 39 per cent by weight available chlorine.

(c) Glacial acetic acid

(d) Starch indicator.

3C.2.2—*Procedure:*

3C.2.2.1. Measure accurately 20 ml of the sample, transfer it to a 1-liter volumetric flask, and make up to volume with distilled water.

3C.2.2.2. Measure 25 ml of the solution from the 1-liter flask into a 250-ml Erlenmeyer flask, add approximately 1 g of crystalline potassium iodide, and make acid with approximately 4 ml of glacial acetic acid. Titrate with 0.1*N* sodium thiosulfate, using starch as an indicator near the endpoint.

3C.2.2.3—*Calculation:*

ml 0.1*N* sodium thiosulfate $\times 40 \times 50 \times 0.003546 \times 0.1$ = volume or trade per cent

Sec. 4C—Free Alkali in Sodium Hypochlorite

4C.1—*Reagents:*

(a) 0.1*N* hydrochloric acid

(b) Hydrogen peroxide solution, 3 per cent

(c) Methyl orange indicator.

4C.2—*Procedure:*

4C.2.1. Weigh accurately approximately 10 g of the sodium hypochlorite into a tall-form 200-ml pyrex glass beaker and add hydrogen peroxide until the action ceases. Boil for 2 min and cool.

4C.2.2. Titrate with 0.1*N* hydrochloric acid, using methyl orange as an indicator.

4C.2.3. Titrate the same amount of hydrogen peroxide solution as was added to the sample, using 0.1*N* hydrochloric acid and methyl orange indicator. Subtract this amount from the titration in 4C.2.2.

4C.3—*Calculation:*

$$\frac{\text{net ml } 0.1N \text{ HCl} \times 0.004 \times 100}{\text{weight of sample}} = \text{per cent free alkali as NaOH}$$

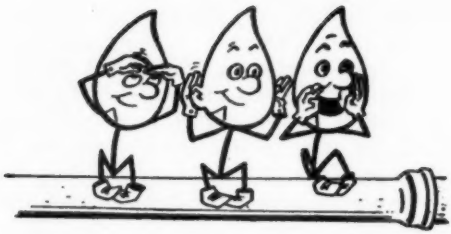
Sec. 5C—Insoluble Matter in Sodium Hypochlorite

5C.1—*Procedure:*

Pour into a 400-ml beaker on a laboratory platform balance approximately 100 ml of the sodium hypochlorite solution and weigh to the nearest 0.1 g. Add 100 ml of distilled water and mix thoroughly. Filter through a tared Gooch crucible. Wash the beaker and crucible with distilled water. Dry the crucible to constant weight at 100°–105°C.

5C.2—*Calculation:*

$$\frac{\text{weight of residue}}{\text{weight of sample}} \times 100 = \text{per cent insoluble matter}$$



Percolation and Runoff

Thirst came first among the causes of fatigue found in a series of tests recently conducted by physiologists of du Pont's Haskell Laboratory of Industrial Toxicology. Dust, noise, vibration, smoke fumes, temperature, and humidity also ran workers down, but thirst came first. Fortunate, then, for our industrial efficiency that thirst is also simplest of solution: mere increased consumption of water has been shown to banish such debilitants as the fatiguing fevers of the "hot industries" and to help workers everywhere to avoid the crippling effects of fatigue. For some time, too, the temperature problem has been almost a snap to solve, to the end that the worker in the average air-conditioned office now gets the equivalent of a third of a ton of ice per day for his personal comfort. And even humidity has yielded to the onslaught of science, humidification and dehumidification equipment becoming so common of late that even the home without a gadget that can remove from 3½ qt to 3 gal from its air is considered almost outhouse in equipage.

Whereas dust, noise, vibration, and smoke fumes have been considered the special problems of individual industries, humidity, temperature, and thirst have always been of universal concern. Thus, it is almost a surprise that, with all the ingeniousness shown in solving these latter problems, no one has yet provided a single solution to all three. Granted that some dehumidifiers also humidify, that some heaters also humidify, that air conditioning does to some extent reduce thirst, we still ought to be able to do better than that. Certainly if a home dehumidifier takes 3 gpd of water out of the air and if an office air conditioner provides what amounts to a third of a ton of ice per day, we should be able to get them together and thus deliver ice water to the thirsty worker at his post. Just think of the added efficiency thereby to be gained. For no matter how conclusive the proof that water does improve efficiency, the water cooler is destined to be known as a social rather than an industrial boon. That thirst does come first in causing fatigue, however, should provide some measure of comfort to the employer in the knowledge that, thereby, even he derives some incidental benefit from the popularity of his water cooler.

(Continued on page 34 P&R)

(*Continued from page 33 P&R*)

The underground of New York City has always been considered a pretty effective setup, but it really knocked itself out last month in putting on a spectacular demonstration within sight of the soap-boxers of Union Square. Within sight was a 300-ft geyser of steam, water, and debris, followed by a 6-ft fountain that continued to flow for almost two hours, making a shambles of a whole city block. Knocked out in the process was all water, steam, sewer, electric, telephone, telegraph, and gas service in the area. Three subway trains were stalled between stations, necessitating evacuation of the passengers along tunnel catwalks, and service as a whole was disrupted until the morning after. Meanwhile, merchants, whose stores line every inch of the street, were flooded practically into bankruptcy, damages to merchandise and equipment running into many thousands of dollars. And even after all utilities had been restored, the street had to be rebuilt because the flood waters had seriously undermined the paving.

Instigator of all this disruption was one CI–36—not Agent 36 of the Communist Internationale at all, but simply one length of cast-iron water pipe, 36 in. in diameter. Having sustained a simple break, the main leaked streams into abutting basements and into a convenient subway, then found its way down to a 16-in. steam main, which exploded with the chill, creating the spectacle as well as helping with the havoc. Little wonder that the effects should be so far reaching when the inventory of the city's underground includes: 110 miles of telegraph cable, 132.49 miles of subway tracks, 4,732 miles of sewers, 50,930 miles of electric cable and wire, 13,000,000 miles of telephone cable and wire, and 5,400 miles of water main, not to mention the 27 miles of pneumatic mail tubes, 75.23 miles of steam main, and 1,177 miles of gas main which also undersqueeze the borough of Manhattan.

Bury me not . . .!

A date has been set for the Public Health Service short course on "Problems of Radioactivity in Water Works," which had been listed with other training courses earlier but not definitely scheduled (August P&R, p. 46). The course will be given November 9–14, 1953, at the Environmental Health Center, Cincinnati, to professional water works personnel applying to Simon Kinsman, Chief, Radiological Health Training Section, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio. The tuition-free course will be devoted to lectures, discussions, and laboratory work designed to give students a working knowledge of radioactive contamination and decontamination, together with maximum permissible concentrations, and will be directed to routine, rather than emergency, conditions.

(*Continued on page 36 P&R*)

No Place for Tastes

No one yet knows the exact chemical composition of algae, but it is common knowledge that algae cause a good part of all the tastes and odors in water supplies. These algae-caused odors are characterized as fishy, aromatic, grassy, earthy, etc. In most cases when Threshold Odor Numbers exceed 5, consumer complaints can be expected.

Algae tastes and odors are attracted to the surface of Aqua Nuchar and held there by strong forces. When the Aqua Nuchar is removed by sedimentation or filtration the tastes and odors are also removed. Complete removal of tastes and odors is better than masking them by a chemical change.

Write to our nearest office and arrange to have one of our Threshold Odor Experts re-evaluate your taste and odor problem in line with the latest procedures developed by our Technical Service Department.

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(Continued from page 34 P&R)

William E. Clow Jr., who only a few months ago (see March P&R, p. 38) was elected chairman of the board of James B. Clow & Sons, died on August 6 at his home in Lake Forest, Ill. He was in his 67th year, and had served the firm for more than 45 years as salesman, sales manager, vice-president, president, and finally board chairman.

Eugene M. Diskant, 31-year-old research chemist with the Los Angeles Dept. of Water & Power, met a tragic death by suicide August 23 when he sealed himself into a cabinet in his laboratory and inhaled carbon monoxide fumes which he generated in a chemical reaction. Known to his associates as a brilliant worker with a rather unhappy emotional adjustment to life, he left a note, according to police, saying he was tired of the "daily struggle leading to nowhere."

R. J. Fitzgerald has been appointed district manager for Electro Rust-Proofing Corp. (N.J.) in the Middle Atlantic States Div., with headquarters at 1113—17th St., N.W., Washington, D.C.

(Continued on page 38 P&R)

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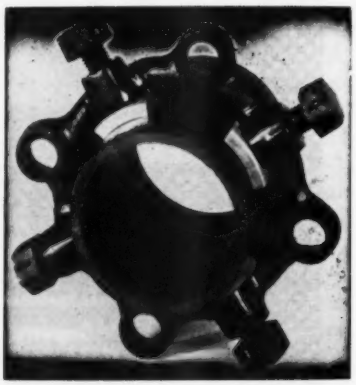

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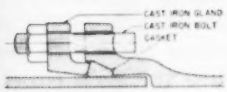

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A. W. W. A.

The use of mechanical joints for pipe, valves and hydrants is growing rapidly. The reasons are easy assembly, saving in time and labor cost, and flexibility that maintains a tight, leak-proof joint under conditions such as pipe line expansion, contraction or settling.

M & H Mechanical Joint hydrant is standard compression type. The main valve opens against the pressure. Hydrant valve will remain closed in case hydrant standpipe is broken off in traffic accident. Other features include low friction loss, revolving head, dry top, easy lubrication. Hydrant shoe has two heavy lugs for use in strapping hydrant to dead-end pipe line.

M & H Mechanical Joints are made in accordance with A.S.A. standard specification A21.11, 1952, as approved by American Water Works Association, in which a thick gasket of triangular cross section is compressed by a bolted follower ring.

For complete information, write or wire M & H VALVE AND FITTINGS COMPANY, Anniston, Alabama.

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

(*Continued from page 36 P&R*)

PEP is a new ASA designation assigned specifically to one Thomas H. Wiggin, AWWA's representative on, and general chairman of, committee A21, following the recent completion of work on nine new cast-iron pipe standards. Actually, not PEP, but "Patience, Endurance, and Persistence" are what ASA paid tribute to in its September *Newsletter*, when it credited Tom with a world's record in those qualities for his 27 years of uninterrupted service as chairman of the A21 group. Among many other sterling qualities that we could add to that list, "Integrity" certainly ranks high, and properly put would make a much more fitting designation—PIPE.

The Scranton Publishing Co. has been formed by E. Scranton Gillette and has taken over the publication of *Water and Sewage Works* from the Gillette Publishing Co., of which Mr. Gillette had been executive vice-president and manager for more than 25 years. The editorial staff of the magazine remains the same under its new direction, with Linn H. Enslow as editor, Harry A. Faber as associate editor, and Fred C. Maurer as assistant editor.

Rigid polyvinyl chloride pipe and fittings have been added to the line of plastic pipe offered by Atlas Mineral Products Co. of Mertztown, Pa., and Houston, Tex. Pipe sizes range from ½ to 4 in., and fittings are molded in sizes up to 2 in. and fabricated in larger sizes. The high impact polyvinyl chloride pipe is distributed under the trade name Pee Vee Cee. Similar pipe offering high chemical resistance is marketed under the Ampcoflex name already in use for the firm's rigid polyvinyl chloride structures.

The enzymes will get you if you don't wash out! So, at least, indicates Dr. Leonard S. Fosdick of Northwestern University, who recently announced development of an enzyme inhibitor which can be used in dentifrices to prevent the formation of tooth-attacking acids in the mouth. "Mankind," he notes, "may be on the verge of success in its long and painful battle with tooth decay." Although the American Dental Assn. has indicated that any conclusions concerning the effectiveness of the inhibitor must be considered premature, toothpaste and mouthwash manufacturers haven't let that bother them. Thus, in the New York area, it is now "Antizyme" in full-page ads and on every drug counter "to stop enzymes from forming acids which cause 98 per cent of tooth cavities and tooth decay." Elsewhere, similarwise, while such recent wonders as chlorophyll and ammoniation bite the dust. Just where, if it is even nearly that good, this will leave fluoridation remains to be seen, but perhaps we can look for the two to complement each other—fluoridation carrying the bulk of the load from the prenatal period through childhood and the enzyme inhibitor picking up with adulthood when the individual is a little more inclined toward responsibility in caring for his own teeth. As for us, even 165 per cent protection seems not a bit too much. Now all we need is something to make ours grow back in again.

A federal charter has been granted to the National Safety Council by act of Congress, thus signalizing the prestige and recognition earned by this active and important public service agency, with which AWWA recently became affiliated as an organization member.

(*Continued on page 40 P&R*)

HYDRO-TITE and FIBREX

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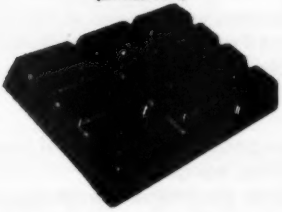
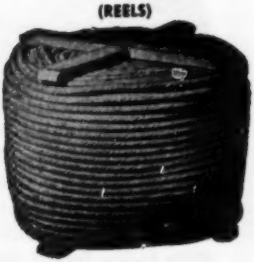
HYDRO-TITE (LITTLEPIGS)



FIBREX (REELS)



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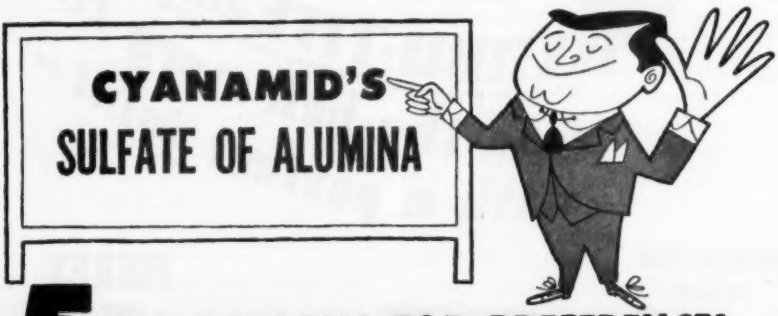
(Continued from page 38 P&R)

Enjoined and not enjoying it was the city of Chicago last month in the process of building the $96,000,000 filtration plant that is to give the city's North Side the same kind of treatment, waterwise, that South Siders have had since the famed South District Filtration Plant began operations in 1947. Principal cause of the nonenjoyment, undoubtedly, is the $3,000,000 already sunk into the bottom of Lake Michigan, from which the plant is to arise, covering an area more than 2,000 ft long and 1,000 ft wide. The suit was brought by property owners along the swank north shore, where, at one point, the plant would be within 500 ft of the Lake Shore Drive. The basis on which the injunction was issued was that the state law permitting the city to build on the submerged lake area was invalid in that the state right was subject to the right of the federal government to control navigation, commerce, and fishery on the lake. But the real reason for the suit was quite clearly worry about bringing the "water works" over to the right side of the tracks. Suspension of work on the project pending appeal of the injunction means merely that much more time before enjoiners become enjoyers of a really good water supply.

Harry L. Holstrum has been appointed manager of the Minneapolis, Minn., plant of Reilly Tar & Chemical Corp. and Republic Creosoting Co. He succeeds A. E. Larkin, who is retiring after 44 years of service, but will continue a consulting connection with the organization.

(Continued on page 42 P&R)



5 BIG REASONS FOR PREFERENCE!

Waterworks superintendents who depend on Cyanamid's Sulfate of Alumina know these five big reasons for its widespread use:

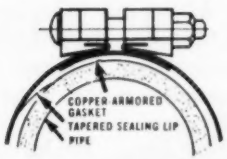
1. **Uniform, trouble-free feeding**
2. **Wide pH range of coagulation**
3. **Rapid floc formation**
4. **Maximum adsorption of suspended and colloidal impurities**
5. **Minimum corrosion of feeding equipment**

Write today for all the details on how these advantages can help you.

AMERICAN Cyanamid COMPANY
Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.
In Canada: North American Cyanamid Limited, Toronto and Montreal

SMITH BLAIR INC.

For PERMANENTLY Repairing Broken or Cracked Pipe



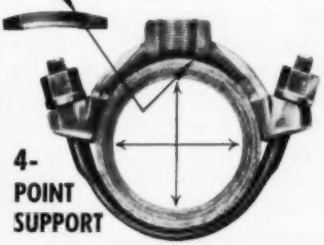
FULL CIRCLE Clamp Couplings

for Cement-Asbestos and Cast Iron Pipe

- Easily installed under pressure in less than 10 minutes
- Permanent—economical—lowers your repair costs
- Actually strengthens the pipe
- Long (two inch) tapered gasket allows for variation in pipe size. Copper armor is molded into the gasket which gives strength, uniform sealing pressure, and ease of installation

WRITE TODAY FOR COMPLETE INFORMATION

NEW! Ductile Iron Taper Seal Service Clamps



4-POINT SUPPORT

- Saddle extends almost half way around pipe to give 4-point support
- Taper seal neoprene gasket with hydromechanical sealing
- Made of the new waterworks material, ductile iron
- Delivered at a low cost to you
- Prompt delivery on all sizes—single, double or triple strap. Taps ½" to 4."

SMITH-BLAIR, INC.

Main Office and Factory: 537 Railroad Avenue, South San Francisco, Calif.

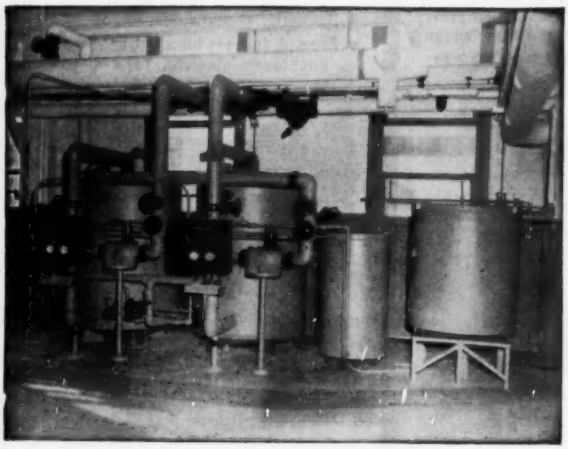
Branches: Greensburg, Pa., and Downey, Calif.

(*Continued from page 40 P&R*)

Saline water desalting is the object of nine research projects sponsored by the Dept. of the Interior, bringing to a total of 11 the active projects for which $123,950 has been allocated. Among the projects are experiments to utilize solar energy for low-cost demineralization, develop synthetic osmotic membranes, improve heat transfer in vapor-compression evaporators, separate salt by a solvent extraction process, and use steam from solar radiation for evaporation. Other workers are investigating inland saline water supplies in South Dakota, reclaimable waste heat sources, and the theoretical minimum thermodynamic energy requirement as a guide to future research. Already in process are studies of an electrical membrane demineralizer and laboratory installations of a diesel waste-heat plant, a temperature-difference plant, and a solar distillation plant (*see* August 1952, p. 690). A survey of the various possible methods was published by the Dept. of the Interior a year ago, and includes an annotated bibliography (*see* Reading Meter, April 1953, p. 52 P&R).

Norvin C. Kiefer, director of the Health & Special Weapons Defense Div. of the Federal Civil Defense Administration, has resigned to become chief medical director of the Equitable Life Assurance Society of the United States. A Public Health Service officer since 1945, Dr. Kiefer has worked on health emergency planning and related matters since 1948.

(*Continued on page 44 P&R*)



Water Softening & Iron Removal* *Deluxe*

JUST WHAT YOU'VE BEEN WAITING FOR—

Complete Water Softening

Complete Iron Removal*

Fully Automatic Operation

All in one single, compact, highly efficient water conditioning plant

Low in cost too—

*Including H_2S removal when required

Write for FREE Bulletins

H-A-T SERVICE

HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY

into the rocky soil
of New England
goes

"Century"®
asbestos-cement pipe

Because "Century" pipe is so easy to handle and assemble, the laying crew works right on the heels of the "digger".

This is typical of certain of the hard, rock-filled soil around South Hadley Falls, Mass., in which "Century" pipe was laid. Engineers: Tighe & Bond, Holyoke, Mass.; Contractor: Ted Ondrick, Chicopee Falls, Mass.

One of the latest installations of "Century" asbestos-cement pressure pipe is at South Hadley Falls, Mass. As with other "Century" installations in rocky New England soil—"the digging was tough, but the laying was easy."

Quick and easy laying is just one of the important advantages of "Century" pipe and its Simplex Couplings. Being made from asbestos fiber and portland cement, it cannot rust or tuberculate. It will carry its rated flow at normal pressure for years and years, keeping pumping costs low.

This durable, economical pipe has served American communities for years, and its use increases each succeeding year. Before *your* community contracts for its next water main, you might like to know more about "Century" asbestos-cement pipe. We shall gladly send you complete information.

Free Booklet "Mains Without Maintenance" gives valuable data, specifications, and reference material for anyone interested in water main pipes. Write for your copy now.

Nature made asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

(Continued from page 42 P&R)

Ethylenediaminetetraacetic acid, the primary reagent in the new compleximetric, or Schwarzenbach, procedure for the determination of water hardness, is now being looked to as the possible answer to still another hardness problem. Already used in the softening of rubber, the chemical has recently demonstrated the ability to soften even the hardened tissue of animal arteries. Experiments on humans have so far been confined to a test on a laboratory corpse, but results were reported as most encouraging, and the research, conducted by Dr. Albert J. Boyle of Wayne Univ., is to continue. Perhaps even before we learn how to say "ethylenediaminetetraacetic acid alleviates arteriosclerosis," the job will have been completed and the initials EDTA, even now being used for the disodium dihydrogen ethylenediaminetetraacetate dihydrate employed in the compleximetric method, will join the list of alphabetical panaceas which began with the vitamins and now range through ACTH and DDT.

Walker Process Equipment, Inc., of Aurora, Ill., is now occupying the modern offices and manufacturing plant

pictured here. Space is also provided in the new building for engineering and laboratory facilities.

(Continued on page 46 P&R)

LIMITORQUE
VALVE CONTROLS

From coast to coast, hundreds of LimiTorque Controls are in service in water works and sewage disposal plants for automatic or push-button operation of valves up to 120 inch diameter. Why is acceptance so widespread? Because LimiTorque Operators are designed to provide dependable, safe and sure valve actuation at all times.

LimiTorque is self-contained and is applicable to all makes of valves. Any available power source may be used to actuate the operator: Electricity, water, air, oil, gas, etc.

A feature of LimiTorque is the torque limit switch which controls the closing thrust on the valve stem and prevents damage to valve operating parts.

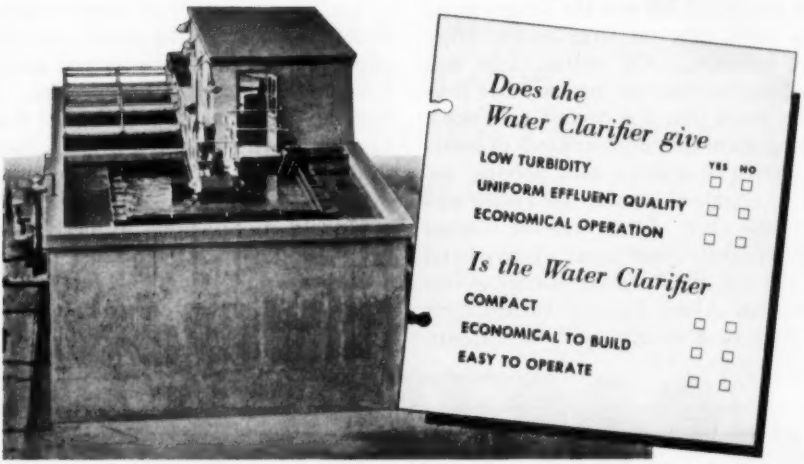
Write for Catalog

PHILADELPHIA GEAR WORKS, Inc.
ERIE AVENUE and G STREET, PHILADELPHIA 34, PA.
New York • Pittsburgh • Chicago • Houston • Lynchburg, Va.

Here's your

Water Clarifier

CHECK LIST



The answer to all these questions is YES . . . if you buy a Graver **REACTIVATOR.**

The photograph presents a good example. It shows a Graver **REACTIVATOR** housed in a plain concrete outer shell in which the **REACTIVATOR** occupies a space only 23 feet square. This Graver unit, together with Graver Gravity Filters and Chemical Feeder, installed alongside, clarifies and also purifies water at the rate of 860,000 gallons per day.

The raw water supply is extremely variable in characteristics. Its turbidity ranges from 20 to 200 ppm. It is highly contaminated with industrial waste. But in spite of these difficult conditions, the Graver **REACTIVATOR** produces an effluent that consistently contains less than 5 ppm turbidity.

Its operating cost is extremely low. Its ability to handle surges is excellent. It can be operated by unskilled personnel.

You can obtain similar results with a Graver **REACTIVATOR.**

Complete information sent upon request.

GRAVER WATER CONDITIONING CO.

Division of Graver Tank & Mfg. Co., Inc.

DEPT. AWW-R, 216 WEST 14TH STREET, NEW YORK 11, N. Y.

In Canada: The Bird-Archer Co., Ltd., Cobourg, Ontario • In Mexico: Proveedores Tecnicos, S. A., Puebla 259, Mexico 7, D. F.

GRAVER *Reactivator*

(Continued from page 44 P&R)

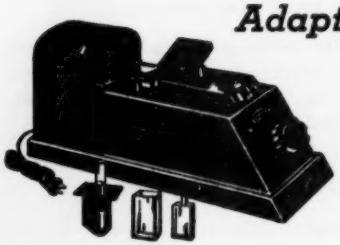
"Idle Rich" could have been the headline for the front-page story last month of the Chicago water distribution division engineer who won first prize in a puzzle contest sponsored by the Unicorn Press as distributors of the *New Funk and Wagnalls Encyclopedia.* Herbert J. Idle was the engineer and $307,500 was the prize—more than three times as large as any other ever awarded. Of course, Idle was anything but that during the more than three years that the contest continued, having spent literally hundreds of hours answering questions and solving rebuses. And, of course, the riches will be a little short of that once the Bureau of Internal Revenue lays its heavy hand on the fat check which former Vice-President Alben Barkley turned over to Idle in a ceremony held (appropriately) on the steps of the old Sub-Treasury Building on a Wall Street corner. But even the estimated $67,658 to $72,245 that Herb will have left after the tax is taken ought to be of considerable help to him in living up to his name when he reaches retirement three years hence—if he wants to, that is, for with a history of acute enigmatism that has, over the years, won him other prizes from cigarettes and skis to a couple thousand other dollars, we have an idea that he'll be busier than ever then, with not even a main break to distract him. Oh, to be Idle!

Harold J. Spaeder, formerly sales engineer for the Dorr Co., is now southeastern representative for Process Engineers Inc., with offices at 163 Forrest Blvd., Decatur, Ga.

(Continued on page 48 P&R)

KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET • NEW YORK, N. Y.

Reduce pipe-line costs...

WITH EASIER, FASTER INSTALLATION OF AMERICAN'S REINFORCED CONCRETE PRESSURE PIPE

Excavation costs are lower. No need for bell holes or excessive trench width. Flexible joints allow for minor changes in grade or alignment — offer protection against normal earth settlement.

Contractors can use standard equipment and semi-skilled labor to lay reinforced concrete pipe. Joint closure is simple and economical. Rubber gasket joints provide a safe, positive closure and eliminate costly welding or caulking.

Immediate backfilling is recommended and eliminates open trench hazards and costly, worrisome traffic problems.

You can realize these savings in installation costs and substantially reduce over all pipe-line costs.

At the same time, the superior design, materials and workmanship which reflect American's 45 years of specialized experience in this field assure you of highest quality and maximum performance.

Write or call today for complete information.

American PIPE AND CONSTRUCTION CO.

Concrete pipe for trunk water supply lines, storm and sanitary sewers, subaqueous pipe lines

P. O. Box 3428, Terminal Annex, Los Angeles 54

Main Offices and Plant: 4929 Firestone Blvd., South Gate, California, LOgan 4-7271

District Sales Offices and Plants: Oakland • San Diego • Portland, Oregon

(Continued from page 46 P&R)

An open-end ratchet wrench said to be eminently suitable for work on connections in meter boxes is being marketed by Tubing Appliance Co.,

10321 Anza Ave., Los Angeles 45, Calif., as the TAC wrench. Handle swing of only 5 deg. will operate the head, and the gripping surfaces engage five sides of a hexagonal fitting for slipless operation. Use of the tool is said to eliminate digging up of meter boxes to obtain sufficient clearance for conventional tools; shown, left, is the tool in use and (inset) in detail.

Lauren W. Grayson, general manager and chief engineer of the Glendale, Calif., Public Service Dept., was elected president of the California Municipal Utilities Assn. at its annual meeting in San Francisco last June.

Roswell M. Roper has retired as engineer and general manager of the Board of Water Commissioners for the East Orange, N.J., Water Dept. He has been succeeded by Charles G. Bourgin, formerly superintendent of the Montclair, N.J., Water Dept.

(Continued on page 50 P&R)

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25K

On Request

JOSEPH G. POLLARD CO., Inc.

Pipe Line Equipment

New Hyde Park **New York**

Now, at a REDUCED PRICE, the accuracy of the loss-in-weight feeding system is available for feeding very small quantities of dry material. Omega's NEW Size "O" Loss-In-Weight Gravimetric Feeder is only about as big as an apartment-sized kitchen range, yet it's capable of feeding up to 100 pounds per hour with an accuracy of 99% or better. Feed rate is adjustable over a 100-to-1 range.

The Size "O" Feeder incorporates all of the Omega Loss-In-Weight features — sentinel alarm to warn of over or under feed, Rotolock mechanism for feeding materials having a tendency to "flood", built-in totalizing counter to check the amount of material fed, and a large five-cubic foot hopper. Write for complete details and price of Omega Size "O" Feeder. Omega Machine Company, 365 Harris Ave., Providence 1, R. I.

OMEGA

B·I·F INDUSTRIES (DIVISION OF B-I-F INDUSTRIES) OMEGA

(Continued from page 48 P&R)

B–I–F Industries, Inc., is the name under which the Providence, R.I., firm of Builders Iron Foundry will henceforth be known. After an exact century of use, the old name has become somewhat inappropriate to describe the precision equipment which the firm produces, and it will be retained in the future only for actual foundry sales. As the parent company of Proportioneers, Inc.; Omega Machine Co.; Builders-Providence, Inc.; and the now subsidiary Builders Iron Foundry, B–I–F Industries offers in its name a remembrance of its origin without too definitely connecting "foundry" with its present products.

High speed computation may be performed on the Burroughs Laboratory Computer, an electronic digital computer utilizing magnetic drum memory systems, punched paper tape input and output facilities, and extensive checking circuits. Further details are available from the Electronic Instruments Div. of Burroughs Corp. (formerly Burroughs Adding Machine Co.), 511 N. Broad St., Philadelphia.

Another perfect tribute—this one to water—was made just last month, by four-year-old Gina Gregory, stand-in for Governor Shivers, at the dedication ceremonies for the new $2,000,000 filtration plant at River Oaks, Tex. Taking a sip from the very first effluent of the new plant, Gina turned to the spectators to announce: "It tastes just like water." Perfect to us, anyway, if a bit puzzling to the spectators, who are reputed not to have seen water for quite a few more years than Gina is old and not to have tasted it for much longer than that.

Not so perfect, though perhaps even more puzzling, was the sign posted on one of the projects of the Paterson, N.J., Board of Public Works during those ten days that seared their world with 100-degree temperatures at the end of August. "No Parking—Snow Removal" was the word! No Board of Public Works might have been the result if it hadn't hurried to explain that no joke was intended, that the supply of road construction signs had been exhausted and it had been necessary to post the new project at once. Whew!

Robert S. Phillips, superintendent of plants for the Charlotte, N.C., Water Dept., has joined the Omega Machine Co. as project engineer. He will be stationed at company headquarters at Providence, R.I.

GUESSING ABOUT BACTERIA?

Why not KNOW!

Your existing personnel can be taught quickly to make bacteriological tests using the new ISOPOR method just as they have learned to make chemical tests such as the determination of residual chlorine and pH. Write for descriptive literature.

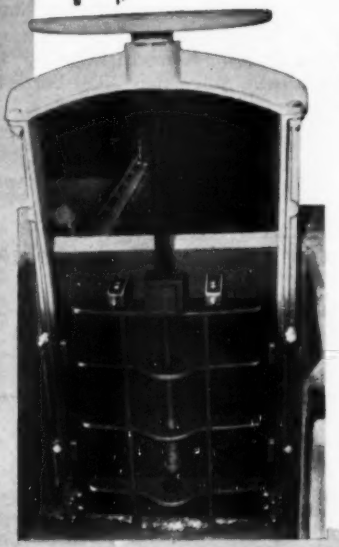
AG Chemical Co., Inc.

P. O. BOX 65 C PASADENA 6, CALIFORNIA

If Noah had known about...

Pekrul Gates

his water control problems might have been easier. There's where **you** have the advantage over poor Noah. PEKRUL Water Control Equipment and PEKRUL engineers stand ready to solve your most difficult requirements.



Manufacturers of Pekrul Gates for

FLOOD CONTROL
LEVEES
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WATER WORKS
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PUMPING PLANTS
OIL REFINERIES
FISH HATCHERIES
REARING PONDS
RECREATION POOLS
COOLING TOWERS
STEEL MILLS

PEKRUL GATE DIVISION

Write for Catalog 49

MORSE BROS. MACHINERY
DENVER, COLORADO

Correspondence

Seventh Sense

To the Editor:

Being a member of our great Association, my conscience wouldn't allow me to sleep at night, if I didn't take exception to your remarks concerning "The Seventh Sense" (August "Reading Meter," P&R, p. 50).

How can you be so positive that the Dowsing Rod in proper hands can be such a useless collection of hearsay and rationalization? Because some noted Geologists have so stated is it proof beyond a reasonable doubt?

I live on Lake George in Warren County where we have had three exceptionally dry years. Wells have gone dry that were never known to before. Farmers have carried water for miles. So what happens? Not a week goes by in the summer months that I am not asked to find water.

So I take my rods, find a vein of water, tell them how deep they must dig, and they dig it. So they have water, and are very happy about it.

Just how popular do you think I would be, if I told some poor farmer to dig down 20 ft, and then he found no water?

Think of the saving when a man can dig 8 or 10 ft and have an ample supply of water, compared to hiring a Well-digger and drilling down 150 ft or more.

Because the rods have appeared to fail in some places does that mean that it has to fail everywhere?

Do you really believe that Geologists can prove that I couldn't find the water that these people are using every day, and are so happy to have?

I agree with Kenneth Roberts. People can believe what they like, but why all the sarcasm and unkind words?

Dowsingly yours,

KENNETH C. PALMER

Water Supt.
Bolton Water Dist.
Bolton Landing, N.Y.; Aug. 31, 1953

(Continued on page 54 P&R)

BOND-O
for Uniformity
NORTHROP & COMPANY, INC.
SPRING VALLEY, N. Y.

Northrop
MACHINE BLENDED
SELF-CAULKING JOINT COMPOUND FOR BELL & SPIGOT CAST IRON WATER PIPE

Today it's Carlon!

Gone are the days of rugged installation work. CARLON Plastic Pipe can be installed faster, easier and without special rigging equipment. It's lightweight . . . flexible . . . and corrosionproof. Connections can be made quickly to CARLON lengths or existing metallic systems.

CARLON is immune to rot, rust and electrolytic action . . . corrosive soils and waters do not affect it. CARLON installations for drainage, sewage, drinking water, gas or electrical conduit require less maintenance . . . replacement is practically eliminated. Install modern pipe for modern requirements. Specify CARLON Plastic Pipe.

CARLON PRODUCTS CORPORATION

Pioneers in Plastic Pipe

CARLON CP

Buy the Pipe with the Stripe!

Write today for catalog

10300 MEECH AVE. • CLEVELAND 5, OHIO

1451-CP

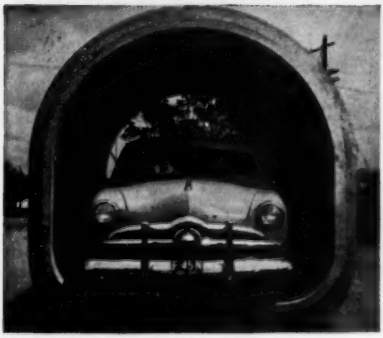
CARLON plastic pipe is produced in Ohio, Colorado, N. Carolina, Oregon, Texas & Ontario.

If it's concrete . . .

UNIVERSAL

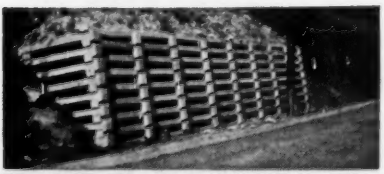
world's largest manufacturer of concrete sewer and culvert pipe

can make it



26 plants for convenient, economical service.

30 years' experience in pipe, cribbing, precast manholes, riverweights, flat base pipe. Name it, we make it!



UNIVERSAL
CONCRETE PIPE CO.
297 South High Street
Columbus, Ohio
Publishers of Famous "Pipe Dreams"

Correspondence

(*Continued from page 52 P&R*)

To the Editor:

I have read (twice) in the August JOURNAL's "Reading Meter" the review of the book *The Seventh Sense* by Kenneth Roberts.

I submit: You should be ashamed of yourself for deigning to delve into the depth of Mr. Roberts' delineation. After all, you are but one of ten (or is it 12?) paid employees of a trade association with a membership of almost 10,000 persons, some of whom have bought Mr. Roberts' books, thereby contributing to his royalties; and since these royalties no doubt amount to more in a day than you are paid in a month (well, anyway, a week), what right have you to question Mr. Roberts?

The words you write are read by but a few thousand, some of whom have expressed the opinion that what you write is so much "junk." On ye other hand, Mr. Roberts, by virtue of having penned some historical best-seller novels, is an expert in the field of divining (if not divinity) and who are such upstarts as you and capable engineers of the ilk of Tom Riddick to question the validity of Mr. Roberts' statements? You quote from Mr. Roberts' book: ". . . water . . . is an overwhelming necessity. . . . People . . . can't get along without water." Can you deny that Mr. Roberts has made a correct statement there? thus proving him to be what he thinks he is—an expert.

Fie on you for five minutes. Next thing I know you will be doubting the theory of Korish, who has proved that the earth is a hollow sphere and that we are on the inside of it.

GEORGE E. SYMONS
Consultant & Technical Editor
Larchmont, N.Y.; Sept. 1, 1953

Not dowsing, but Kenneth Roberts' "scientific" proof of it was the intended butt of our unkindness, so friend Palmer must have been reading between our lines. As for Doc Symons, he's been reading between our ears.—ED.

THE installation of Permutit automatically controlled zeolite water softeners economically solved the problem of hard water for this Florida city. The Automatic Regeneration feature saves valuable man hours, eliminates the possibility of costly human errors, and assures a constant supply of clear, soft water.

Well water of 20 grains hardness is softened by Permutit Q, the high capacity sodium cation exchanger, which in this installation is regenerated with brine from a nearby salt well.

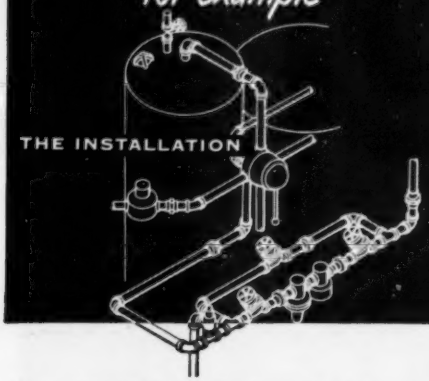
Consulting Engineers, Russell & Axon of Daytona Beach, Florida, planned the layout and recommended Permutit Automatic Equipment and high capacity Permutit Q. For information concerning your city's water problems write to: THE PERMUTIT COMPANY, Dept. JA-10, 330 West 42nd Street, New York 36, N. Y.

WATER CONDITIONING HEADQUARTERS
FOR OVER 40 YEARS

PERMUTIT®

This Valve Stops the "Up" in Upkeep

...on Water Service Piping, for example



VALVE SERVICE RATINGS

SUITABILITY:	Doing what other valves couldn't
FEATURES:	Packless - Long Life Diaphragm
MAINTENANCE COST:	No regular maintenance needed
SERVICE LIFE:	Outlasting other valves many times
OPERATING RESULTS:	Safety Hazard to personnel stopped
AVAILABILITY:	Crane catalog item - No. 1610

At the Excello Paper Products Co., Inc., Cincinnati, using Crane Diaphragm valves on city water supply lines; also on plant service water piping, hot and cold.

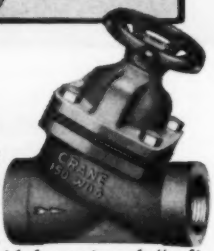
THE CASE HISTORY

Typical of many processes using a lot of water, this plant has numerous open end lines and hose connections. And because of very frequent operation, the valves formerly used in these lines required more than usual servicing to keep up with leakage, dripping hose lines, and hazardous, messy floors.

Crane No. 1610 Diaphragm valves were selected to replace the troublesome conventional valves. Immediately these packless valves stopped the annoyance and expense of stuffing box and seat leakage. Their pliable disc insert ring made a tight seat on open end lines with minimum effort on handwheels.

The replacements were started about 2 years ago. With no attention whatsoever, all Crane Diaphragm valves remain tight, and the plant's water leakage problem remains solved.

THE VALVE



Water is but one of hundreds of fluids Crane Packless Diaphragm valves handle efficiently. Their sealed-to-fluid bonnet and "soft-seating" disc are ideal for all sorts of hard-to-hold liquids and gases; also for sludges, slurries, etc. Separate disc and diaphragm design saves diaphragm wear; permits tight seating even should diaphragm fail. Choose these valves from a wide range of materials, lined or unlined body, for corrosive or ordinary applications. See your Crane Catalog, or Crane Representative.

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CHEMICAL ANALYSIS

Determination of Submicrogram Quantities of Arsenic by Radioactivation. II. Determination of Arsenic in Sea Water. A. A. SMALES & B. D. PATE. Analyst, **77**: 188 ('52). Application of radioactivation to determination of As in small samples of sea water from selected points off Cornish coast is described. Determination involves [1] direct activation of sample for 70 hr by slow-neutron irradiation; [2] chemical separation by distillation of activated As after addition of sodium arsenate to act as carrier and as check on chemical yield; [3] estimation of activity radiometrically by means of Geiger counter; [4] confirmation that As^{76} isotope is being counted by determination of half-life and max. β-energy. Standard solution of As is treated similarly. Avg As content found in sea water was 2.6 μg/l, with range of 1.6–5.0 μg/l.—*PHEA*

Determination of Chloride Ion in Condensed Water. G. B. SMIT. Anal. Chim. Acta, **7**:330 ('52) (in French). Titration of Cl^- with Hg^+ according to Clarke allows detn. of lower concns. than is possible by Mohr's method. Greater sharpness of end-point at lower concns. and use of more dil. Hg^+ soln. permit further lowering of concn. limit down to 0.05 ppm Cl^- when calibration curve is used, remarkable form of which may perhaps be attributed to formation of $HgCl_2 \cdot 2HgO$. This sensitivity allows Cl^- detns. in boiler condensates and wetness detn. of steam. —*CA*

Direct Titrimetric Determination of Fluoride in Natural Waters. A. M. BOND & M. M. MURRAY. Biochem. J., **53**:642 ('53). Procedure is based on direct titration of F with $Th(NO_3)_4$ soln., with Na alizarin sulfonate as indicator. Titration is carried out at pH 3.3 in presence of AcOH, and interference by SO_4^{2-}, PO_4^{3-}, CO_3^{2-}, or HCO_3^- is eliminated by prior treatment with $BaCl_2$. *Reagents:* [1] fresh soln. of 0.0004*M* $Th(NO_3)_4 \cdot 4H_2O$ prepd. by dilg. stock soln. contg. 5.52 g/l; [2] NaF standard, contg. 1 ml $\equiv$ 5 γ F, made fresh from soln. contg. 2.21 g/l NaF; [3] approx. 0.4*N* AcOH made by dilg. 23 ml glacial AcOH to one l; [4] approx. 0.05*N* NaOH; [5] approx. 0.05*N* HCl; [6] approx. 0.1*N* $Na_2S_2O_3$; [7] 0.03% (wt./vol.) Na alizarin sulfonate; and [8] 5% (wt./vol.) $BaCl_2$. *Procedure:* Pipet 10 ml of $BaCl_2$ soln. into 100-ml water sample, heat to boiling, cool immediately, and filter. Measure accurately 20-ml aliquots into Nessler tubes, add 1 ml alizarin, and adjust pH so that soln. is orange yellow. Add few drops of AcOH to lemon-yellow color, and add 1 ml more of AcOH. Remove Cl with drop of 0.1*N* $Na_2S_2O_3$, make up to about 50-ml vol. with distd. H_2O, and titrate dropwise with $Th(NO_3)_4$, with vigorous stirring, until color matches titration blank. Make up to 50 ml before final reading (titration blank: 47.5 ml H_2O, 1 ml alizarin, 1 ml 0.4*N* AcOH, 1 drop $Na_2S_2O_3$, and accurately measured 0.3 ml $Th(NO_3)_4$). Ca and Mg as found in hard water do not interfere. Of 295 samples of water in Great Britain only 7 contained more than 1 ppm of F.—*CA*

Direct Titrimetric Determination of Fluorine in Drinking Waters. A. M. BOND & M. M. MURRAY. J. Physiol., **116**:18P ('52). F is titrated at controlled pH with thorium NO_3^- (I) and alizarin; Ca, PO_4^{3-}, SO_4^{2-} interfere with titration. To avoid this, steam distn. in presence of acid to drive off HF may precede titration, or Ca can be removed by running H_2O through column of Zeokarb 215, and other ions by addn. of $BaCl_2$ soln. and filtration, pH adjustment, and titration as indicated in 0.008*M* acetate buffer with 0.0016*N* I. F^- in 0.2 ppm (0.2 γ/ml) or more in natural H_2O can be estd. by this method.—*CA*

Determination of a Minute Quantity of Indium in Mineral Water. N. IKEDA.

(*Continued on page 64*)

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(*Continued from page 62*)

J. Chem. Soc. Japan, Pure Chem. Sec., **74**:91 ('53). pH of water was adjusted to 5–6, and it was extd. by CCl_4 soln. of dithizone. Evapd. residue is treated with HNO_3, and 10 mg of $NaNO_3$ is added. Mixt. was arced in C electrodes, and In content was detd. by comparing with spectra of standard samples. Max. content found in 34 spring waters was of order of 0.1–1 γ/l.—*CA*

Determination of Microquantities of Iodine in Water Solution by Amperometric Titrations. H. P. KRAMER, W. A. MOORE & D. G. BALLINGER. Anal. Chem., **24**:1892 ('52). Amperometric titration method for determining microquantities of iodine has distinct advantage of ability to determine concentration of germicidal entities actually present at pH levels within practical range of water treatment practice. Effect of ammonia on iodine residuals under conditions of this investigation was found to be negligible. Oxidation state of iodine in water solution is function of time and pH. At given pH, free iodine residuals diminish as function of time. This loss in free iodine concentration is caused by oxidation-reduction reaction of hypoiodous acid, which results in formation of iodate and iodide ions. Selection of system of buffers which minimized catalytic action encountered with certain buffers and use of chlorine demand–free water resulted in negligible loss of free iodine in 30-min contact period. In order to secure precise results when utilizing amperometric titration method, electrodes should be sensitized by appropriate procedure. Determination of free iodine by amperometric method was found to be accurate to $\pm$ 0.01 ppm in concentrations varying from 0.2 to 2.0 ppm.—*CA*

Determination of Naphthalene in Industrial Wastes. A. L. MEDIN & L. K. HERNDON. Sew. Ind. Wastes, **24**:1260 ('52). Naphthalene is trade waste for which no analytical methods were available for measuring extent of pollution in small concentra-

(*Continued on page 66*)

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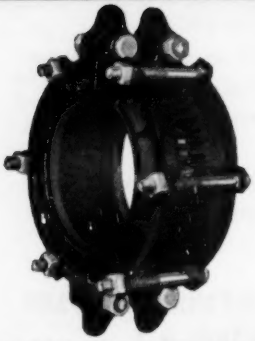

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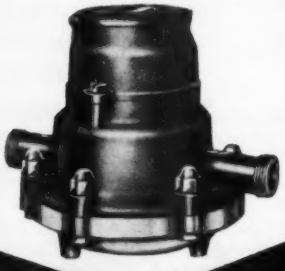

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(*Continued from page 64*)

tions, such as 5 ppm, when it is toxic to aquatic life. Procedure has been developed, based on reaction described by Schwartz, to produce fluorescein from naphthalene, by oxidation, formation of napthaquinone, nitration, and sulfonation. Final color varies from light to deep blue, depending on quality of naphthalene. It is applicable from 0.2 to 200 ppm at accuracy of 5.6%. Anhydrous aluminum chloride, chloroform, 1% sodium hydroxide solution, and alum are required. If sulfides are present in water to be analyzed, 10% silver nitrate and 10% sodium hydroxide solution are also required. To prevent water interferences, all apparatus should be carefully dried before use. Phenol does not interfere with analysis, nor does anthracene; sulfides have to be removed to prevent interference. To find optimum frequency for determination of naphthalene, absorption curve was developed. From optimum frequencies, compared with selected frequency in electrophotometer, degree of transmission was determined for various concentrations of naphthalene.—*PHEA*

Determination of Titanium in Mineral Waters. K. KIMURA, N. IKEDA & H. WATANABE. J. Chem. Soc. Japan, Pure Chem. Sec., **73**:584 ('52). Water sample is acidified with HCl, and Fe present is oxidized by HNO_3. If Fe is absent, 100 mg of Fe is added as carrier. $Fe(OH)_3$ ppt. is formed by adding 1% NaOH, filtering, and dissolving in hot dil. H_2SO_4. After cooling, H_3PO_4 is added until color of Fe has vanished. Yellow color of Ti is produced by adding 2 ml of 30% H_2O_2 and is compared with std. by Pulfrich photometer with S45 filter. Isobe Spring in Toyama Prefecture contained 12 ppm Ti, highest value hitherto reported in Japan.—*CA*

Stable Indicator Solutions for the Complexiometric Determination of Total Hardness in Water. E. M. DISKANT. Anal. Chem., **24**:1856 ('52). Solns. contg. 0.5 g of Pontachrome Black TA dissolved in 50 ml of either diethanolamine or triethanolamine remained in good condition for at least 6 mo. Addn. of other solvents or salts is not recommended. Indicator solns. should be kept tightly closed. No advantage was gained by protecting against light or by storage in refrigerator.—*CA*

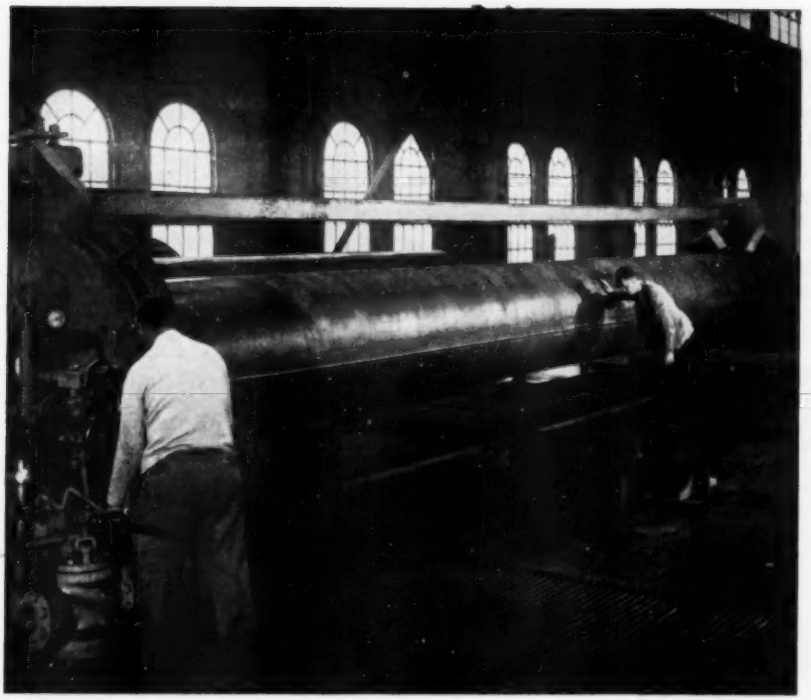
Determination of Hardness of Waters Containing Polyphosphates. M. BROOKE & M. HOLBROOK. Chemist Analyst, **41**:80 ('52). Ion-exchange method was found successful in detg. hardness in waters contg. polyphosphates. Amberlite IR-4B served as exchanger. Water to be tested is passed through exchange column at rate of 5–10 ml per min. First 100 ml are discarded, and std. procedure with di-Na ethylenediaminetetraacetate is run over next 50 ml.—*CA*

Determination of Organic Matter in Water. A Note on the Value of the Kubel-Tiemann Method. R. WILBAUX. Bul. Agr. Congo Belge, **43**:751 ('52). Accuracy of manganimetric method is lessened with waters contg. heavy amts. of org. matter. In such instances, preliminary assay, following AOAC method, and use of 50% excess of $KMnO_4$ is recommended.—*CA*

The Distinguishing of Organic Matter in Water. H. IVEKOVIC & A. GERTNER. Anal. Chim. Acta, **7**:396 ('52) (in English). Method for distinguishing org. matter in water consists of detn. of O_2 consumed, by means of $KMnO_4$ or NaOCl, in time intervals of 15, 30, and 60 (or 120) min, resp., from which it is possible to plot curve representing oxidation velocity. Oxidizability of org. matter in water can be expressed numerically by ratio of O_2 consumed within 30 and 15 min, or within 60 and 30 min, resp. (relation of oxidizability). Quicker oxidation of org. matter takes place, the more relation of oxidizability approaches the value of 1; this indicates recent poln.—*CA*

New Physicochemical Methods for the Analysis of Water. K. A. MURRAY. S. African Ind. Chemist, **6**:270 ('52). Brief notes are given on following detns.: Nitrite is detd. by mixing 5 ml of nitrite soln., 10 ml 0.01*M* KI, and 5 ml *N* H_2SO_4 (all O free) to half cell and detg. potential of I_2–I electrode. O is detd. in similar manner with 0.02*M* KI. Sulfide is detd. by its catalytic effect on reaction between azide and I; amt. of N evolved is measured manometrically. Sulfide is also detd. by generating I electrically in presence of azide. Excess I is detected only after all S has been destroyed. K is detd. by volumetric method with dilituric acid. Dild. sewage liquors can be

(*Continued on page 68*)



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BETHLEHEM *Tar-Enameled* WATER PIPE

(Continued from page 66)

distinguished from nitrified effluents by detg. O uptake of 5-ml samples to which 0.5 ml of MacConkey broth (double strength) and 1 ml 5% $NaNO_2$ soln. have been added.—*CA*

Detection of Petroleum Products in Spring Waters. F. DANGL & B. NIETSCH. Mikrochemie ver. Mikrochim Acta, **39**:336 ('52). Expts. are described to show that seepage of petroleum into springs can be detected and detd. approx. by fluorescence shown in ultraviolet light. As little as 0.001 γ of petroleum can be detected in 1 l of water.—*CA*

A Colorimetric Method for Determining Pine Oil in Water. J. A. SUTTON. U.S. Bur. Mines Rpt. Invest., No. 4990 ('53). In connection with research project on stream pollution, colorimetric method was developed for concns. of 1–30 ppm of pine oil in H_2O. Method depends on stable bluish-green color produced when pine oil is made to react with vanillin-HCl reagent at 60° for 25 min. Colorimetric reaction actually dets. α-terpineol, chief component in pine oil. If sample is taken from process equipment so that it may contain undissolved oil, its vol. should be at least 1 l and it should be shaken at least 5 min before analyzing. If more than 30 ppm of pine oil is found, sample may contain undissolved oil and should be dild. with oil-free H_2O. When using transfer pipets add waste H_2O 15, EtOH 5, and vanillin-HCl reagent 30 ml to glass-stoppered volumetric flask, shake 1 min, and place 25 min in 60° temp.-controlled water bath. Cool flask to room temp. in tap water bath, and shake again. Transfer approx. 15 ml to cylindrical cell of electrophotometer. Color intensity is evaluated as scale reading against distd. H_2O, and reading is converted to ppm, according to calibration curve for specific pine oil in use at plant. Blank is run to insure that reagent imparts no color to oil-free H_2O. If waste H_2O is colored, distd. H_2O in reference cell of electrophotometer should be replaced with mixt. of waste H_2O 15, alc. 5, and HCl 30 ml.—*CA*

(Continued on page 70)

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(*Continued from page 68*)

The Determination of Surface-active Agents. G. R. LEWIS & L. K. HERNDON. Sew. Ind. Wastes, **24**:1456 ('52). Of 2 determination methods selected and investigated, 2-phase titration is most suitable for determination of anionic surface-active agents in industrial wastes and polluted waters. Desirable points, such as elimination of soaps, feasibility of concentration by boiling, simplicity of procedure, independence from pH effects, rapidity of determinations, and simplicity of apparatus, recommend 2-phase titration over turbidimetric method. Testing done in river water and sewage gave an indication of satisfactory performance in presence of number of organic substances. Tests of 2-phase method under different conditions would be useful in evaluating its reliability. Further testing of Brilliant Blue FCF as indicator is also recommended.—*PHEA*

FOREIGN WATER SUPPLIES—GENERAL

Treatment of Water for Regional Supply [Australia]. W. L. HALE. Commonwealth Engr., **40**:271 ('53). System of Australian water supply for 6,100-sq mi area serving 40,000 people comprises headworks and treatment plant. Latter consists of coagulation and settling basin, with chemical treatment using filter alum; flocculation basin, 73,000-gal capac.; and settling basin, 500,000-gal capac. Turbidity of raw water varies from 5,000 to 40 ppm—stays at 500–1,500 ppm for long periods. In '51, 402 tons (Imp.) of material was removed from water, avg 9 tons per day. Water is obtained from river by 4 pumps, capac. 60,000–90,000 gph. Rapid sand filter capac. is 178,000 gph. During peak demands, 205 gph was handled. After filtration water is chlorinated and lime added; 2,270 acre-ft treated in '51. Entire system is operated by one man. Water distribution system consists of 2-mil gal reservoirs which are adequate only for 4 or 5 hr at peak demand. Pump capac. is 40,000 gph. Various villages and stations have separate reservoirs with capac. ranging from 50,000 to 1,000,000 gal. Maximum distance from treatment plant is 100 mi.—*PHEA*

Peak Load Pumping Stations Will Boost City Water Supply [Australia]. ANON. Commonwealth Engr., **40**:183 ('52). Article gives description of 7 new pumping stations that will add 10 mgd to Melbourne's water supply. Description of pumps and control equipment is given. Stations will be used until larger gravity mains can be installed; considering this, pairs of smaller pumps were adopted so they can be used elsewhere singly later on. Stations are under pressure on suction side normally, but during pumping negative head of 5′ is produced.—*PHEA*

Tomago Sandbeds Water Supply Scheme [Australia]. ANON. Commonwealth Engr., **39**:409 ('52). This article gives history and operating details of one of Australia's most interesting water supply schemes. Tomago sandbeds, only 10 mi from steel city of Newcastle, N.S.W., act as huge underground reservoir for rainwater. 4″-diam. wells, in groups of 60, have been sunk to 44′ into sand. Each group is header-connected to primary pumping unit to give yield of 1 mgd. There are 15 of these primary pumping units and another 5 are to be provided. Water delivered from primary pumps is sprayed into air to remove H_2S and CO_2, treated with chlorine, lime and alum, and pumped to sedimentation basin, from which flow is by gravitation to second distribution reservoir. Article discusses geology of beds, replenishment of water by rain, capac. of beds, effect of pumping on ground water level, and final development.—*PHEA*

The New Broadside Filters of the Stirlingshire and Falkirk Water Board [Gt. Br.]. ANON. Wtr. & Wtr. Eng. (Br.), **56**:469 ('52). Treatment plant consists of 24 upflow settling tanks operating at vertical velocity of 0.75 ipm and 12 rapid gravity filters with rating of 75 gph (Imp.)/sq ft. Water rises from filters into clear-water balancing tank of 2-mil gal capac. Capac. of plant is 12 mgd, with provision for extension to 20 mgd. Administration bldg. is on 3 floors. Ground floor houses pumps, workshop area, lime tanks, storeroom, cloakroom, and lavatory. Entrance on first floor is utilized as administration hall, in which are controls for operating plant. Office and switchgear are on first floor, and laboratory is on second floor. Two main bldgs., chemical house and administration bldg., are separated by filters and settling tanks. State of every filter and every operation of plant

(*Continued on page 72*)

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(Continued from page 70)

can be seen from one point in administration hall. Plant is one of largest and best equipped in world.—*H. E. Babbitt*

Experiments in Primary Filtration of Severn Water and Extensions to Worcester Waterworks [Gt. Br.]. H. A. MACKRILL. Wtr. & Wtr. Eng. (Br.), **56**: 423 ('52). Water is taken from River Severn approx. 1½ mi upstream. Existing purification works have relied on plain sedimentation and slow sand filtration followed by chlorination. Experiments have been conducted for number of years with object of saving, by primary filtration, time and cost of cleaning slow sand filters. Reconstruction works, based on results of experiments, have been completed at approx. cost of £200,000 and consist of settling tank with capac. of 1 mil gal (Imp.), representing 1 day's supply from works when extended, 6 primary filters, and new screen intake capable of passing 10 mgd.—*H. E. Babbitt*

Coventry's River Severn Water Supply Scheme [Gt. Br.]. ANON. Surveyor, **62**: 359 ('53). Coventry Corporation officially opened first portion of its River Severn Water Supply Scheme in April of this year. Water works with capacity of 6 mgd (Imp.) cost £2,000,000. Plan, which eventually calls for 10 mgd, was initiated in '35, but postponed due to war. Authority for construction of portion just completed was obtained in '47. Diagram of main works and description and approximate cost of river inlet, raw-water pumps, treatment works, high-lift pumps, reservoirs, and pipelines are given. Treatment facilities include 3″ coarse screen; 2 band screens; flash mixers for adding alum and lime; 8 primary and 12 secondary upflow sludge blanket sedimentation tanks having final upward velocities of 6′ and 4′/hr, respectively; 6 rapid gravity filters to operate at nominal rate of 91 gph (Imp.)/sq ft with head loss of 16′ and to be cleaned by air scour and water backwash; and 2 0.5-mil gal contact tanks, which may be operated in series or parallel. Provision was also made for chlorination of water between primary and secondary sedimentation tanks and at beginning and middle of contact tank. Dechlorination will be effected by use of sulfur dioxide, and ammonia will be used to stabilize chlorine residual. Activated carbon can be added to filter inlet should taste or odor problems occur, and lime is added at filter effluent to reduce corrosion. Bredon Hill and Meriden reservoirs and pipelines are also briefly described.—*PHEA*

Making the Water of the Thames Fit to Drink [Gt. Br.]. G. CARTER. Munic. Eng. Sanit. Record (Br.), **128**:25 ('51). Describes the stages in the treatment of water from the Thames for the Metropolitan Water Board. The control of algae growth in the reservoirs and the chlorination of the water from secondary filters are discussed.—*PHEA*

Regional Water Scheme for the County of Midlothian [Gt. Br.]. ANON. Surveyor, **112**:387 ('53). Rosebery filtration works, near Gorebridge, which were opened recently as part of regional plan, are described. Works, located about 12 mi south of Edinburgh, will provide initial output of about 3 mgd, representing requirements of population of approximately 60,000. Works consist of microstraining plant, slow sand filters, and

(Continued on page 74)

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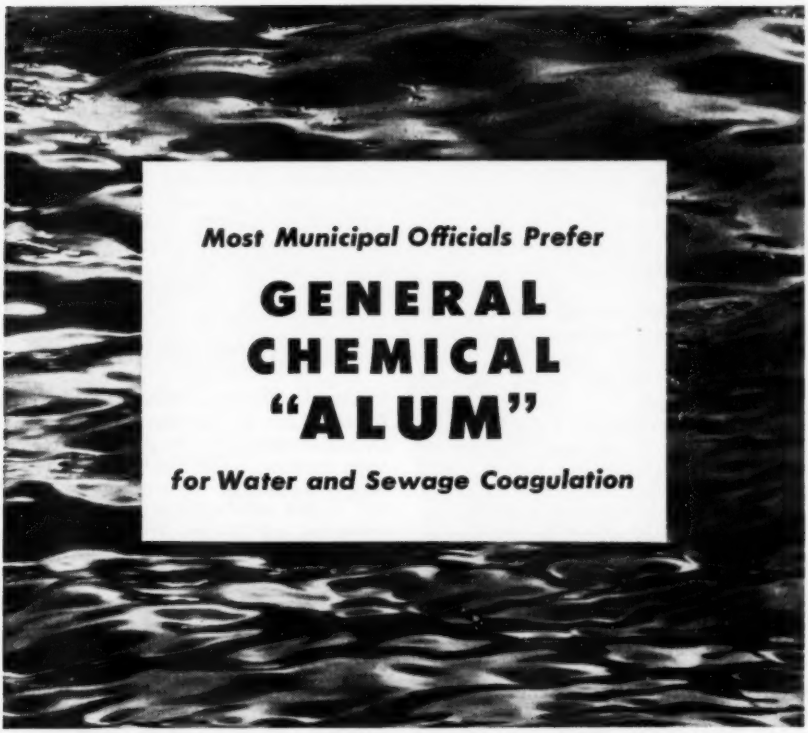

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(*Continued from page 72*)

2-mil gal clear-water tank. Microstrainers are used to remove all but minutest particles of suspended matter and microorganisms, thereby increasing duration of filter runs. Strainers and other units, as well as distribution system, are described. Rosebery works cost £103,000. Approximately £344,000 spent so far on county scheme. It is estimated that to complete scheme will cost additional £175,000.—*PHEA.*

Fruid-Menzion Scheme of the City of Edinburgh Water Department [Gt. Br.]. ANON. Wtr. & Wtr. Eng. (Br.), **57**:49 ('53). Scheme will add approx. 6 mgd (Imp.) to water supply resources. Scheme provided for impounding of Talla Water in 2,800-mil gal (Imp.) reservoir, diversion of Menzion Burn into Talla Res. and impounding of Fruid water, and impounding of Tweed. Second development provided for impounding of Fruid water in reservoir of 1,600-mil gal (Imp.) capac. Works are, essentially, intakes on Fruid water and Menzion Burn, inner half of river diversion and outlet tunnel of future Fruid Res., and aqueduct therefrom to Talla Res.—*H. E. Babbitt*

The Aucha Lochy Water Scheme of the Royal Burgh of Campbeltown [Gt. Br.]. ANON. Wtr. & Wtr. Eng. (Br.), **56**:381 ('52). 4 small catchment areas have been combined with available supply of 777,000 gpd (Imp.) for population of 13,000. Present population is 7,200. New purification plant has capac. of 0.5 mgd, is pressure operated throughout, and includes acid dosing for pH adjustment of raw water, coagulation with alum, 15-min retention in pressure type contact tanks, filtration through pressure filters, and chlorination.—*H. E. Babbitt*

The Vaitarna Scheme of the Bombay Water Supply [India]. ANON. Wtr. & Wtr. Eng. (Br.), **57**:135 ('53). Water requirements by '56 will be 236 mgd (Imp.), and 25–50 yr from now will be 440 mgd. Present safe supply is 79 mgd. Vaitarnacum-Tansa scheme consists mainly of 260′ gravity dam impounding max. of 54 bil gal and net of 42 bil gal. Reservoir is connected to Tansa Lake by tunnel with equivalent diam. of about 10′ and about 20,000′ long. New 96″ pipeline will be laid along existing pair to Powai, distance of 46 mi. Catchment area of proposed dam site is 174 sq mi, giving annual avg yield of 150,000 mil gal and min. of 42,000. Max. flood discharge is estimated at 92,000 cfs, although once in 1,000 yr may amount to 200,000 cfs. Spillway crest level is 24′ below full supply level. Rock for dam construction is quarried and crushed near site, and aggregates and water are cooled to pouring temp. of 60°F. Tunnels, which have been completed, have capacity of 500 mgd with 60′ head of water. All contracts have now been let at estimated cost of 16 crores (approx. $30,000,000).—*H. E. Babbitt*

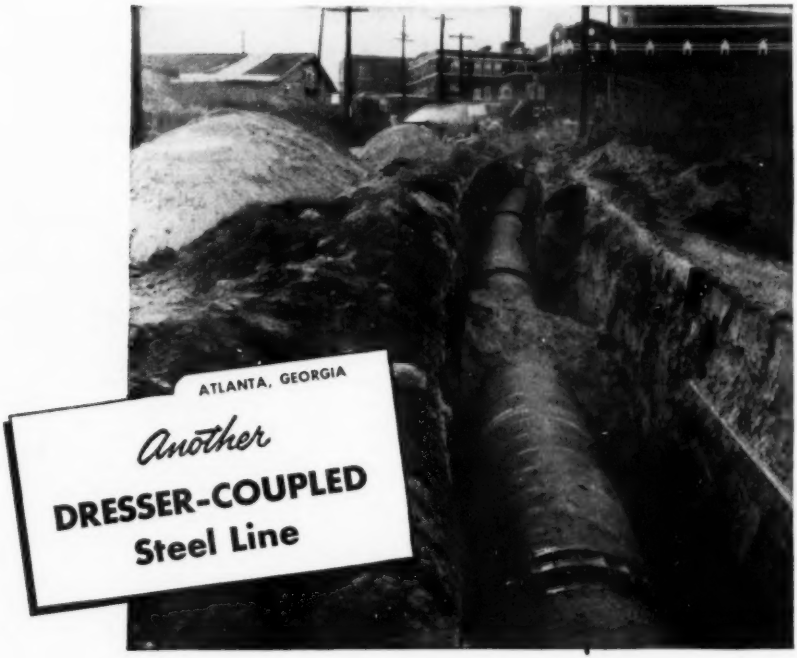
SOURCE OF SUPPLY

California Proposes Diversion of Feather River Water to Southern California. A. D. EDMONSTON. Civ. Eng., **4**:41 (Apr. '53). Investigations made by Calif. Water Resources Board for development of plan for full control and utilization of state's water resources and preliminary conclusions are presented in this article. Comparisons between ultimate water needs and available supplies in different parts of state were made; and proposed plans for supplying deficient areas with water from areas having excess resources are briefly described. It is concluded that adequate water supplies can be developed from California's own resources (including Colorado River rights) to meet probable ultimate needs of state. Sea water conversion, cloud seeding, and sewage and waste water reclamation are mentioned as possible sources under study.—*PHEA*

Fluoride Content Water Supplies of New Mexico. ANON. New Mexico Health Officer, **19**:1:3 ('53). Routine monthly water sampling program for fluoride content was established and carried on by Dept. of Public Health for 15 mo to revise data on fluoride content and to observe fluctuations in N.M. water supplies. Results indicate defluoridation should be considered by many N.M. communities, whereas others may wish to consider supplementation. Tables present max., min., and avg content of various N.M. water supplies.—*PHEA*

Chemical Analyses of Water Supplies in New Mexico. ANON. New Mexico Health Officer, **19**:1:9 (53). Survey was made by Dept. of Public Health to revise data available on chemical characteristics of N.M. water supplies. Need was evident as state has

(*Continued on page 76*)



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(Continued from page 74)

doubled in population, new supplies have been developed, and old supplies renovated since '32, date of last general publication. Tables give results of analyses for public water supplies in state.—*PHEA*

Puerto Rico Develops Safe Water Supplies for Its Citizens. S. CUEVAS. Civ. Eng., **22**:533 ('52). After generalizing on improvements to better health and social conditions, highways, public housing, hydroelectric and steam electric power plants, and industrial development, author describes work of Puerto Rico Aqueduct and Sewer Authority, particularly Rio Grande de Loíza project, water development undertaking comprising masonry dam, 4 mi of 48" reinforced concrete pipe, and 30-mil gal filtration plant (mixing, flocculation, settling, rapid sand filtration, and chlorination). Puerto Rico Water Authority was formed in '45. Island itself is 3,400 sq mi in extent, of which 40% is arable land having avg population density of 2.5 per acre. 40% of population uses only 15 gpcd of water. Other 60% uses 50–100 gpcd, depending upon and increasing with size of city.—*PHEA*

Fresh Water From Sea Water by Solar Distillation. M. TELKES. Ind. Eng. Chem., **45**:1108 ('53). Principles of heat transfer and life raft solar still designs are discussed. Transmittance losses due to reflectance of transparent surfaces or fog particles in light receiver may be considerable (e.g., untreated Vinylite may reflect 40% of incident solar radiation). Heat loss through evaporator foundation, as high as 400 Btu/sq ft/hr for concrete and as low as 21 with suitable dry insulators, can be decreased to 6% of available energy by insulator 1" thick. Heat loss from reradiation, when temp. of evapg. pan is 150°F and that of condensing surface is 127°F, will be about 10% of solar energy received. Insulated solar stills ran at 65–70% thermal efficiency with input of 200–300 Btu/sq ft/hr. Tests carried out in absence of sun with electrically heated stills showed insulator ($k = 0.3$) 1" thick is sufficient; higher ambient temp. slightly increases efficiency and wind has no significant effect. Depth of feedwater should be about ½". Estd. costs of fresh-water distn. from sea and general economics are treated.—*CA*

New Apparatus Extracts Salt From Ocean Water. Ice & Refrig., **122**:23 (Mar. '52). Construction of small portable pilot plant to test design of revolutionary app. for desalting sea water was started in Jan. '52 by Los Angeles refrigeration consultant. According to designer's contract with Neb. corporation, test plant must be able to freshen salt water at rate of 150 gph. Proposed design calls for trailer-mounted installation 7½' long, 4½' wide, 8½' high, and weighing approx. 3,000 lb. This plant, upon completion, will be demonstrated to water officials of Southern California communities. Patent application for desalting of sea water has been made on principle that water boils at much lower temp. at less than atmospheric pressure. By using partial vacuum in app., designer claims that cost of heat can be elimd. from distn. process. Basically, app. consists of circulation system in which scale formation is prevented by continuous discharge of salt brine and other impurities to waste. Primary obstacle in operation of any distn. app., according to designer, is

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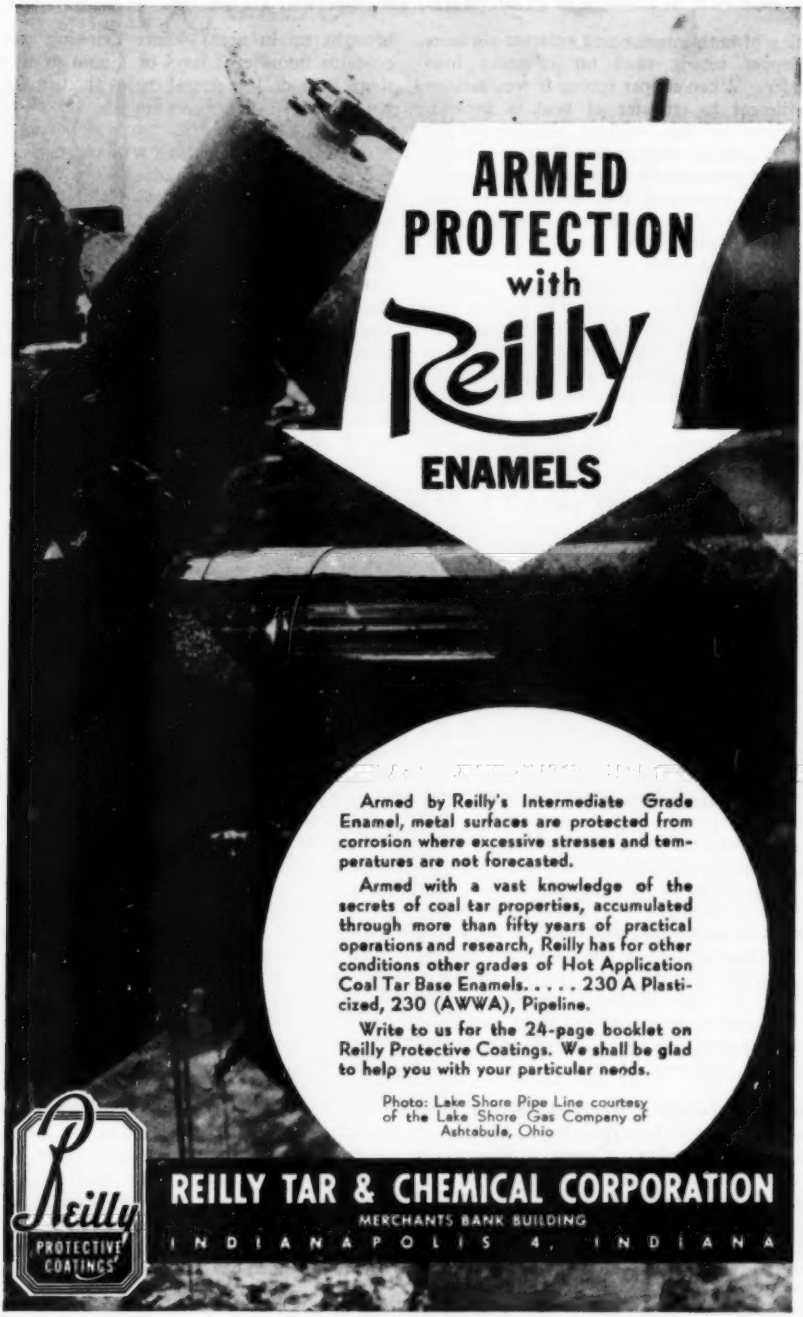
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(*Continued from page 76*)

wetting of both interior and exterior surfaces of copper tubing used for effecting heat transfer. When copper tubing is wet, serious impediment to transfer of heat is present. Resistance of this surface phenomenon to heat transfer is such that even thin film of water on one or both sides will retard process. It is contended that resistance to heat transfer offered by surface films can be elimd. by coating surface of copper tubing both inside and out with some of new forms of carbon compounds. This carbon coating, reportedly, will keep surface of tubing perfectly dry even when submerged. As consequence, eff. of app. will be greatly improved. On basis of these non-wetable surfaces, designer believes it will be possible to produce distd. water at cost equivalent to domestic water in Los Angeles area.—*PHEA*

FLUORIDATION

Effect of Fluoridated Public Water Supplies on Dental Caries Prevalence. F. A. Arnold, H. T. Dean & J. W. Knutson. Pub. Health Rpts., **68**:141 ('53). Seventh annual dental examn. of children after starting fluoridation at Grand Rapids, Mich., was completed during Nov. '52. Results show that there was reduction in dental-caries rates in permanent teeth of Grand Rapids children, ranging from 66.6% in 6-yr-old children to 18.1% in 16-yr-old group. 58% reduction was observed for deciduous teeth of 5-yr-old group. Similar reductions were not observed at Muskegon, Mich., where water supply remained fluoride free. Change in caries rates at Grand Rapids was confirmed by objective assessment, that is, reduction in no. of missing teeth. Comparison of '51 rates at Grand Rapids with those of Aurora, Ill. (where water supply naturally contains 1.2 ppm fluoride), shows that use of fluoridated water gives same beneficial effects as does use of natural-fluoride water of similar concn.—*F. J. Maier*

The Fluoridation of Domestic Water Supplies in North America as a Means of Controlling Dental Caries. Report of United Kingdom Mission, Feb.–Apr. '52. H.M. Stationery Office, London, Eng. ('53). Epidemiological studies in America have demonstrated beyond doubt that among children and adults who have been born and brought up in areas where drinking water contains fluoride at level of 1 ppm or more, there is much less dental caries than in areas where water is free from fluoride. Compared with areas where drinking water contains little or no fluoride, there is about 60% less dental caries among children aged 12–14 yr and about 6 times as many children have permanent teeth which are free from caries (18–29% compared to about 4%). In recent years many North American communities whose water supplies contained little or no fluoride have added fluorine compounds to their water. In certain of these communities dental effects of fluoridation have been studied carefully. In committee's opinion, evidence is conclusive that, among children in fluoridation areas, there is reduction in incidence of dental caries to level comparable with that experienced where fluoride occurs naturally in water. To date, reduction of this extent has been demonstrated only among children up to 6 yr of age, because no fluoridation scheme has been in progress for more than 7 yr. Data relating to older age groups are as yet insufficient to warrant firm conclusions. There is nothing to suggest that water containing fluoride naturally derived has properties different from those of water to which fluoride has been added. At concentration of fluoride used, about 1.0 ppm, it is fluoride ion that is operative, and nature of salt used is of secondary importance. Committee considers that artificially fluoridated water is similar in its action to one containing naturally derived fluoride. There is, therefore, sufficient evidence to indicate that benefits derived by young children will accompany them into adult life. It is realized that time alone can demonstrate truth of this contention. Doubt has been expressed about risk of mottled enamel. It has been stated that 10% of children drinking fluoridated water may develop very mild mottling of teeth. This is not hazard. Committee observed that, when mottling occurs, it amounts only to occasional white fleck in enamel, so slight that it cannot be recognized without expert examination. Appearance of teeth is excellent. Committee found no scientific evidence that there is any danger to health from continued consumption of water containing fluoride in low concentration. In areas where naturally occurring fluorides are present at level of 1.0 ppm, mortality statistics do not indicate

(*Continued on page 80*)

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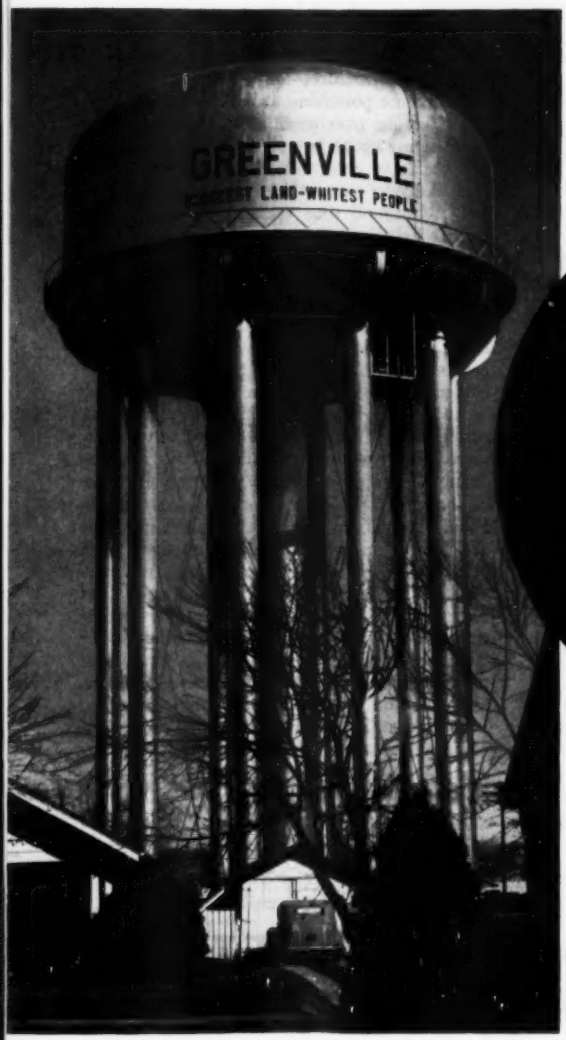

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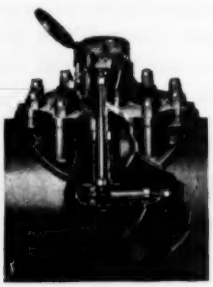
(Continued from page 78)

any hazard due to fluorides, and medical experience in such areas has not produced any evidence of increased morbidity. Many suggestions have been made that certain ill effects may nevertheless occur. Committee can only comment that proving of negative is extremely difficult. Meanwhile, millions of people are living in ordinary good health on waters containing fluorides at levels of 1 ppm or more. Committee could not find any evidence that fluoridated water had an adverse effect on industrial processes. Mechanical addition of fluoride to water supply at any desired level presents few difficulties. With correctly designed plant and proper controls, there is no danger of adding toxic overdose of fluoride. Methods of administering fluorides in which individual can exercise choice are at present few, and positive control can be exercised only in topical application of solution of sodium fluoride. This method has not given same degree of protection against dental caries as fluoridation of water, nor has its effect been as lasting. Another method, whereby tablets of sodium fluoride are dissolved in drinking water for individual or family, may have some use in region lacking piped supply, but its careless use may be ineffectual and even risky. In committee's opinion, fluoridation of water supplies is preferable to all other methods. —*Ed.*

Toxicological Evidence for the Safety of the Fluoridation of Public Water Supplies. F. F. HEYROTH. Am. J. Pub. Health, **42**:1568 ('52). In acute poisoning by fluorine there is hemorrhagic gastroenteritis and acute toxic nephritis, accompanied by varying degree of damage to liver. Lethal dose is, however, large; reports give it as 50–200 mg of fluoride ion per kg of body weight in rabbits, while in human self-experiments as much as 250 mg of sodium fluoride has been taken in one dose without harm. It is suggested, therefore, that there need be no fear of acute poisoning as result of accidental or deliberate overfluoridation of water supply. Many experiments with animals have been made to determine daily intake of fluorine likely to cause chronic poisoning, but it has been found that variations for different animal species are so great that these experiments cannot safely be used for predicting what may occur in man. Author, however, gives results of some experiments with human beings, one of whom took more than 20 g of sodium fluoride over period of 120 weeks without showing any radiographic evidence of changes in bone density. He also records that man and his wife, life-long residents in Texas district where water contained 8 ppm fluorine, showed no osseous changes whatever. There is some evidence of endemic skeletal fluorosis occuring in India, China, and South Africa, but no cases are known in which skeletal changes have occurred in regions where there is no mottling of teeth. There is no evidence that waterborne fluoride has been cause of nephritis. Only when fluorine content of water supply exceeds 5–6 ppm will its prolonged use give rise to detectable osseous changes, and then only in most susceptible persons. Fluoridation of water to 1 ppm level is procedure with ample margin of safety.—*BH*

Why Fluoridation? ANON. Can. Chem. Processing, **36**:11:85 (Nov. '52). Following aspects discussed: dental benefits, claims of

(Continued on page 82)



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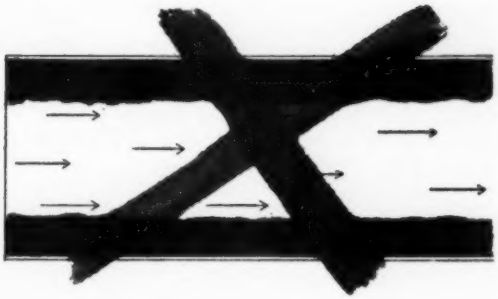
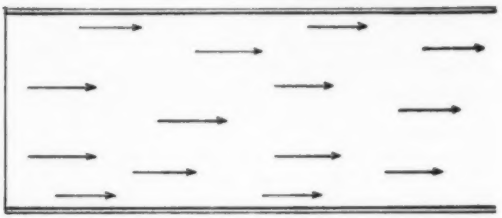


flow capacity stays high



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(*Continued from page 80*)

ill effects on health of adults, effect on industrial use, effect on water purif. procedures, chemicals used, cost, feeders, dosage, extent practiced. App. for domestic fluoridation will soon be available in Canada at cost of about $100. Application controlled by flow of water into house by means of rotating injector in water service to premises. NaF soln., strength about 2% depending upon F^- content of local supply, stored in 2-gal tank, sufficient for 6-mo supply.—*R. E. Thompson*

Resolutions on Water Fluoridation. W.W. Inf. Exch.—Can. Sec., AWWA, **8**:A:1:1 (Mar. '53). Can. Pub. Health Assn. recommends (June '52) "fluoridation of community water supplies for the reduction of dental caries in those communities where there is at present an insufficient fluoride content for this purpose, and where the procedure can be adequately controlled and supervised." Can. Dental Assn. and Can. Medical Assn. joint committee stated (Jan. 27, '53): it has been found that children in communities with water supply adjusted to 1 ppm F content since '45 have considerably less tooth decay than children whose water supply practically F free; protection from caries conferred by naturally fluoridated water carried over into adult years; not yet known whether artificially fluoridated water acts similarly; no evidence of ill effects when F content 1–1.2 ppm; in areas where F occurs naturally in water supply, some children develop mild tooth mottling, commonly detectable only by experienced observers, when F content about 1.5 ppm; communities considering fluoridation should first discuss subject with local dental, medical, and water works authorities; steps must be taken to insure that F intake from sources other than water not excessive. Dental Public Health Committee of Ontario Dental Assn. recommends (Feb. 2, '53) fluoridation of public water supplies as "a safe and effective preventive measure for reducing the prevalence of dental caries."—*R. E. Thompson*

Treatment of Fluorinated Aluminum-bearing Mineral Products. W. E. WHITE. U.S. 2,643,179 (June 23, '53). Method is disclosed for production and utilization of F-bearing bauxite for municipal water treatment to supply F as well as clarifying agent ($Al_2(SO_4)_3$). One part F-bearing mineral (which may be waste byproduct, such as spent bauxite obtained by sorption of F from alkylated petroleum products) is treated with 2 parts H_2SO_4 and 30 parts H_2O at 80° or higher for 2 hr with constant stirring. Insolubles are filtered off, and filtrate is evapd. to dryness. Dry solids ($AlFSO_4$) are pulverized and then added to water as required. This is followed by settling or filtration stage. F and sulfate content of reagent can be varied by altering Al_2O_3-H_2SO_4 ratio. —*CA*

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OTHER ARTICLES NOTED

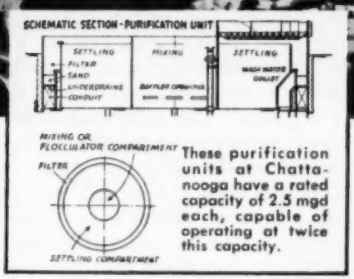
Recent articles of interest, not abstracted, are listed below.

Political Aspects of Water Rate Making. C. K. MATHEWS. W.W. Eng., **106**:694 (Aug. '53).

Pumps and Pumping Stations. R. HAZEN. J. NEWWA, **67**:114 (June '53).

Fundamental Principles of Handling Chlorine. Part II. V. W. LANGWORTHY. Wtr. & Sew. Wks., **100**:318 (Aug. '53).

Information courtesy Mr. E. H. Aldrich, Chief Engineer, American Water Works Service Co., Philadelphia, Pa.



These purification units at Chattanooga have a rated capacity of 2.5 mgd each, capable of operating at twice this capacity.

Two years ago, this entirely new design developed by American Water Works Service Company was installed in Alexandria, Va. Instead of the conventional layout, with separate structures for mixing, settling, etc., this plant has *"purification units."* Each unit incorporates all the major purification operations . . . i.e. after the raw water is chemically treated, it receives the usual mixing, coagulating, settling, and filtering, all in the same steel tank (see drawing).

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The Reading Meter

Public Health Engineering. *Peter C. G. Isaac. Foreword by Gordon M. Fair. Spon's Civil Engineering Series, E. & F. N. Spon, Ltd., 22 Henrietta St., London, W.C. 2, England (1953) 277 pp.; 36s. (approx. $5.05 U.S.)*

This careful and well documented text is devoted almost entirely to water and wastes, thus avoiding the skimpy treatment too often characteristic of books on the wider aspects of public health. Although British, the author has studied for a time with Harvard's Gordon Fair, and so has the advantage of being familiar with methods and techniques on both sides of the Atlantic. This internationalism is a decided advantage; too often new developments remain confined to their country of origin until old enough and well enough known to convince an overseas manufacturer that he can safely begin a campaign of production and promotion. With minor exceptions, the illustrations are clear and helpful.

Today's Revolution in Weather. *William J. Baxter. International Economic Research Bureau, 68 William St., New York 5, N.Y. (1953) 131 pp.; paperbound; $1.00 (clothbound ed., $3.00)*

There is much that is entertaining in this rambling tour, much that is amusing —particularly the illustrations by cartoonist Virgil Partch (ViP)—and even much that is interesting and stimulating. But, strictly interpreted, there is no evidence in this book for the weather revolution that is to make the Southwest hotter and drier, the northern lands of the globe warmer. Mr. Baxter drives his point home with random observations by such authorities as the fur merchant who remembers when women took their warm wraps out of storage in November, whereas today's milder winters [or tougher women?] leave the furs in storage much longer. Anybody who has taken the trouble to glance at the record assembled by Pierce and Vogt (May 1953 JOURNAL, p. 508) of 92 years of measurement of level fluctuations in the Great Lakes will be thunderstruck (the old-fangled bolt-of-Jupiter variety) at Mr. Baxter's brashness in substituting casual impressions for scientific observation. In speaking of a trip to Niagara Falls, which he had not seen for some years, he reports: "I was amazed at the rise in the level of the lakes and the increased amount of water flowing over as a result of the warming climate." Others will be amazed, too.

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water. *ASTM Special Technical Pub. No. 130, American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. (1953) 54 pp.; paperbound; $1.50*

This symposium on the application of automatic operation to water and waste analysis in industry was presented at the June 24 meeting of ASTM in New York. The five authors and their discussers review actual and potential means of automatic sampling; measurement of pH, conductivity, and oxidation-reduction potential; chlorine residuals and demand; color, turbidity, hardness, and silica; and dissolved gases. The paper on recording chlorine residuals is by A. E. Griffin, who discusses the Wallace & Tiernan amperometric residual chlorine recorder.

(Continued on page 86 P&R)

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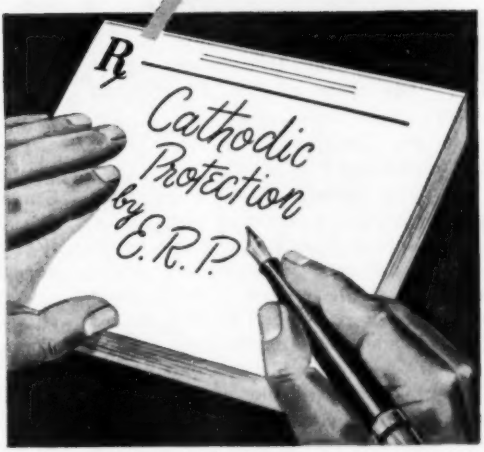

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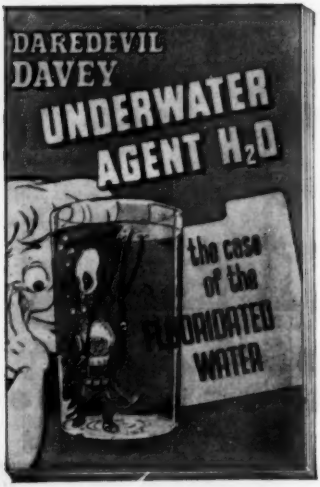
The Reading Meter

(Continued from page 84 P&R)



Daredevil Davey, Underwater Agent H_2O. The Case of the Fluoridated Water. *Am. Dental Assn., 222 E. Superior St., Chicago 11, Ill. (1952) 16 pp.; paperbound.*

Daredevil Davey, ADA's comic book hero, already had a record of many amazing adventures in and out of this world to delight and enlighten junior size dental patients in the techniques of tooth maintenance and repair when he took on the role of Underwater Agent H_2O. Thus, it ought to be quite obvious that he has all the answers to all those questions and arguments and charges most frequently asked and used and leveled at proponents of fluoridation everywhere. For this very reason, as a matter of fact, some of Davey's defenses seem directed considerably over junior's head to the supposedly sophisticated seniors who will make him wait his turn for the book, either in the waiting room or at home. Even so, the pictures will undoubtedly attract children a great deal more than most waiting room literature and out of the presentation at least those beyond their milk teeth miseries ought to absorb a general impression that fluoridation is what the "good guys" want.

Although the wordiness and complexity of both argument and approach make the book less effective than most educational comics, they seem necessary to the subject. What does seem unnecessary, though, is the harshness with which the opponents to fluoridation are depicted. Anyone who believes some of the arguments against fluoridation isn't particularly going to enjoy being held up as a Class 1 dope before his children—nor is he likely to be converted by Davey's daredevilry. All of which leads us back to the conviction that to fluoridate or not to fluoridate is for the experts to argue, not for the layman and certainly not for the layboy. When Davey demonstrates proper techniques in brushing and caring for teeth, he does an effective job of education; in *The Case of the Fluoridated Water*, he lectures on organic chemistry to grade schoolers—biting off more than even he can chew.

The Industrial Utility of Public Water Supplies in the New England States, 1952. *E. W. Lohr & W. F. White. Circular 288, Geological Survey, Washington 25, D.C. (1953) 80 pp.; paperbound; free*

With this summary of the chemical character of the public water supplies of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont, the Geological Survey concludes its series of nine circulars on the country's water supplies. A full report that will consolidate the regional ones and add some new data on smaller towns is expected; but meanwhile the individual reports provide a source of useful and helpful information that was sorely needed. In addition to providing raw and finished water analyses, the reports include some background information on the plant, its source of supply, ownership, storage facilities, and the type of treatment provided. Previous reports were reviewed in "The Reading Meter" for October and December 1952, and January, May, July, and September 1953.

(Continued on page 88 P&R)

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The Reading Meter

(Continued from page 86 P&R)

Proceedings of the Regional Technical Conference on Flood Control in Asia and the Far East. *Flood Control Series No. 3, United Nations Economic Commission for Asia and the Far East, Bangkok (1952) 320 pp.; paperbound; $3.00 U.S. from Columbia Univ. Press, 2960 Broadway, New York 27, N.Y., as Sales No. 1953.II.F.1*

This English-language publication of the proceedings of a flood control conference held at New Delhi, India, during January 1951, includes 32 formal papers and abstracts of on-the-spot discussions. The various authors consider the significance to their respective regions of soil and water conservation, river control with and without dikes, silt transportation, erosion, and rainfall. A brief comment by the World Health Organization emphasizes the secondary benefits to be gained from river control: improved physical and bacterial quality of public water supplies taken from flood-control impounding reservoirs, and improved self-purification of polluted streams when regulated to avoid extremes of low and high flow.

Engineering—A Creative Profession. *Engineers' Council for Professional Development, 29 W. 39th St., New York 18, N.Y. (1953) 32 pp.; paperbound; 25¢*

This guide for the high school student discusses the various types of work engineers do, with whom and what they work, their usual pattern of education and training, and the specific engineering fields and their accomplishments. The booklet replaces "Engineering as a Career."

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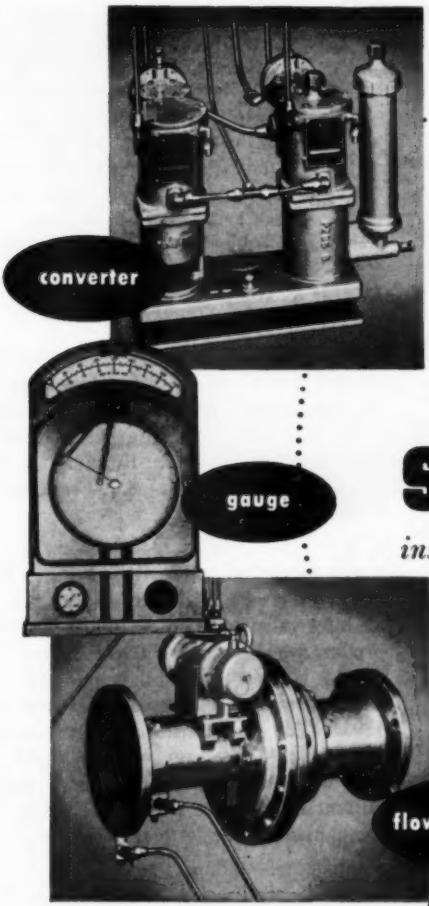

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Electronic control applications for industrial processes are described in a 76-page collection of case studies entitled "Cutting Production Costs With Electronic Controls." Offered by Photoswitch, Inc., Cambridge, Mass.

Motor starters offering protection against short circuits, overloads, low voltage, and, for synchronous motors, out-of-step operation, are described in a 12-page booklet offered by Allis-Chalmers Mfg. Co., 1026 S. 70th St., Milwaukee, Wis. The Type H starters are intended for 2,200 to 5,000-v. squirrel-cage, wound rotor, and synchronous motors.

A methyl purple indicator that is claimed to offer greater sensitivity and more clearly distinguishable color change than methyl orange is described in an 8-page booklet distributed by Fleisher Chemical Co., Benjamin Franklin Sta., Washington 4, D.C. Sample bottles of the indicator are also offered for trial use.

"Automatic pH Control in Water and Industrial Waste Treatment" is discussed in Bul. 55 of Milton Roy Co., Sta. E, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Steel piping standards and codes are featured in the first issue of the new Taylor Forge & Pipe Works house organ, which numbers 48 pages. Requests for copies should be addressed to the company at Box 485, Chicago 90, Ill. In addition to reproducing much of the tabular material from relevant codes, a summary of related literature and specifications is also included.

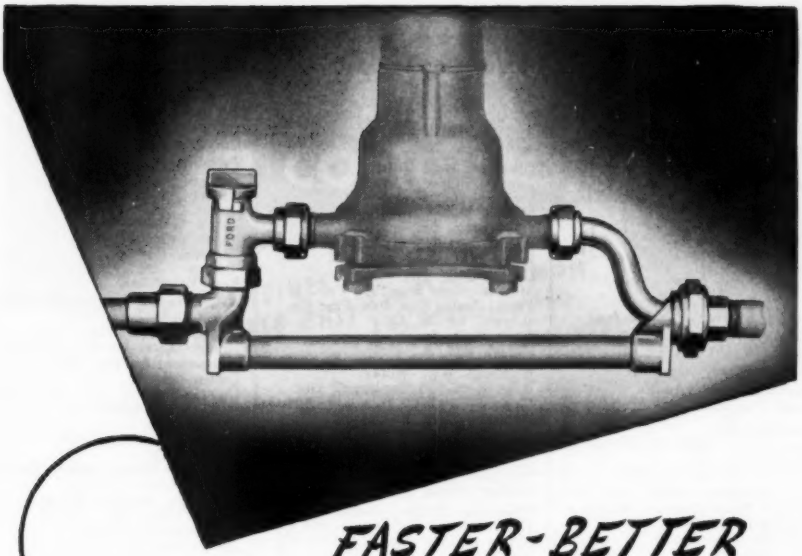
Sheltered yard storage of supplies or equipment by utilization of Yard-Stor sectional, movable huts, which can be tilted, nested, telescoped and otherwise maneuvered on its track mounting to permit ready inspection or free access of material handling equipment. An alternative use suggested is to cover pipe-laying operations in bad weather. A descriptive folder may be obtained from Yard-Stor Shelter Co., 19256 John R, Detroit 3, Mich.

Impervious membrane linings for reservoirs are described in a folder describing the Laykold Weathercoat. The membrane is a spray-applied asphalt emulsion produced by American Bitumuls & Asphalt Co., 200 Bush St., San Francisco 4, Calif.

An air relief valve for pipelines that acts either as a vent for trapped air or an inlet valve to break vacuums has been produced by Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia 42, Pa., and is described in a 4-page bulletin, No. 1203. The mechanism actually employs two valves—one large one for rapid action, and a smaller one for minor, intermittent adjustment without bringing the mechanism of the larger into play.

"An Introduction to Flowrator Meters" is a 16-page catalog of these instruments which explains their design and operation. The bulletin goes into particular explanation of the difference in application of the basic flow equation, $Q = AC\sqrt{2gh}$, which in the Flowrator is directed to measurement of A, a linear factor, rather than the head loss h, which is logarithmic. The booklet is available from Fischer & Porter Co., Hatboro, Pa.

Pipe repair clamps for bolted repair of pipe from ½ to 14 in. in size are cataloged and illustrated in a folder distributed by Morris Coupling & Clamp Co., Ellwood City, Pa.



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Morse Bros. Mchy. Co.
Southern Pipe & Casing Co.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Prof. Services, pp. 25–29)

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Infilco Inc.
Permutit Co.

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Johns-Manville Corp.
Infilco Inc.
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Filters, incl. Feedwater:
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Dorr Co.
Infilco Inc.
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Permutit Co.
Roberts Filter Mfg. Co.
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Filtration Plant Equipment:
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Permutit Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Welsbach Corp., Ozone Processes Div.

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James Jones Co.
Mueller Co.

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Cast Iron Pipe Research Assn.
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Flocculating Equipment:
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Permutit Co.
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Walker Process Equipment, Inc.

Fluoride Chemicals:
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American FLOCSETTLER

PROVIDES COMPLETE, EFFICIENT

WATER CONDITIONING

COMBINES IN ONE UNIT
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2. FLOCCULATION
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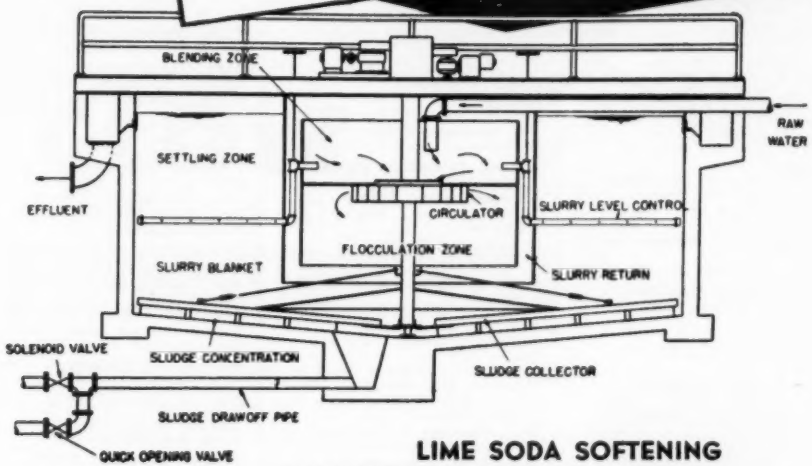
4. SLUDGE REMOVAL



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The AMERICAN Flocsettler contains in one unit all the modern features of water and waste treatment including mixing and slurry blending, slurry recirculation, sludge blanket settling, sludge concentration, and sludge removal. Each of the above features is positive and adjustable with the AMERICAN Flocsettler. Design permits immediate normal operation after shut-downs.

SEND FOR TECHNICAL SUPPLEMENT FL AND COMPLETE DESIGN DATA

Our staff of Sanitary Engineers will cooperate with consulting and operating engineers in suggesting the process of treatment and type of equipment best suited to individual needs.

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ENDURING PROTECTION

as traffic rumbles on!

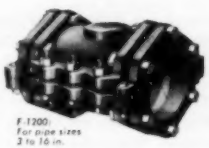
Reinforce all hard-to-get-at pipe joints with

CLOW

MECHANICAL JOINT

BELL SPLIT SLEEVES

Under the constant impact of ponderous, ever-increasing rail and vehicular traffic on our highways and railways, crossing underground water pipe lines require added protection. That is why foresight is so important. *Play it safe*—don't wait for a break. Install Clow Mechanical Joint Bell Split Sleeves as *original equipment* wherever pipe must pass under highway truck routes and railroad tracks. Specify them for marshlands and under water—everywhere pipe is not readily accessible in case of an emergency. Clow Mechanical Joint Split Sleeves are easy to install—no lead, jute, or calking.



F-1200 Clow Mechanical Joint Straight Split Sleeves are ideal for permanent repairs to pipe barrels. 12-in. and smaller sizes will repair any lengthwise break up to 8 in.; 14- and 16-in. sizes, to 17 in.

Write for illustrated circular containing full particulars and other pertinent information.

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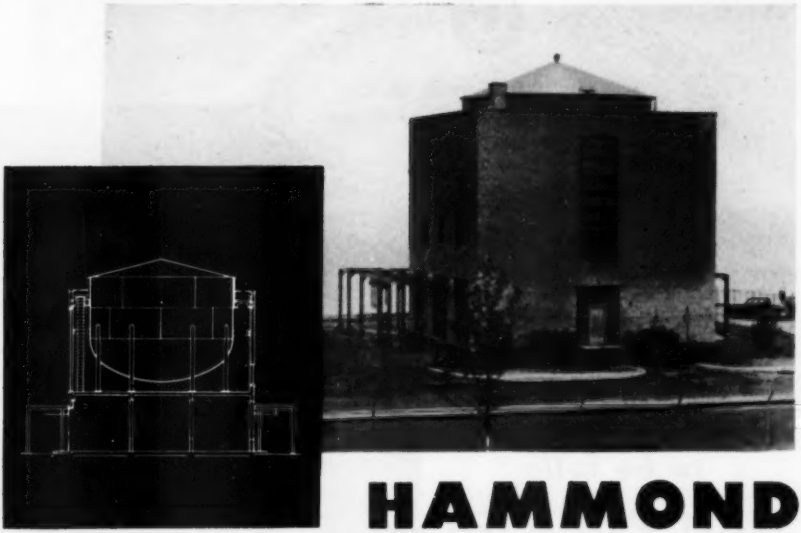
A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.



HAMMOND

concentrated sewage sludge

STORAGE TANK

Housed in brick to conform with the architecture of its environs.

This Hammond designed and erected concentrated sewage sludge storage tank, at the Rockaway, New York plant, built by the Department of Public Works, is 38 feet in diameter and 38 feet high and has a capacity of 200,000 gallons. Its cone roof and ellipsoidal bottom are designed so that the concentrated sludge is gravity fed to sludge vessels which dock at the base of its installation on Jamaica Bay. The clear liquor on the top is decanted into the plant influent.

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The Symbol for Service, Quality and Performance in Water Meters

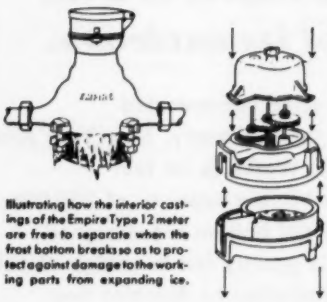
ROCKWELL EMPIRE TYPE 12 METER

The First Meter to be fully

FROST PROTECTED

INTERNALLY

HERE'S HOW IT WORKS



Illustrating how the interior castings of the Empire Type 12 meter are free to separate when the frost bottom breaks so as to protect against damage to the working parts from expanding ice.

WHEN METER FREEZES . . .

ALL PARTS SEPARATE

In all other meter designs the interior parts are bolted together and, in some, the interior assembly is directly attached to the meter casing at the stuffing box.

In the Empire Type 12 meter *alone,* the interior castings are jointed and held together without the use of screws or bolts. Thus, when an Empire meter freezes, the bottom plate breaks and the parts all come apart. They are then free to move with the expanding ice and are thus protected against strain or distortion. This money saving feature of Empire Type 12 meters is fully described in bulletin W-802. Write for your copy today.

. . . *and the* EMPIRE TYPE 14

AN ALL-BRONZE METER FOR WARM CLIMATES

Especially designed for use below the frost belt. All-bronze construction presents many advantages including ability to combat electrolytic action. Exclusive design using oscillating piston principle has fewer working parts than any other meter. Described in bulletin W-801.

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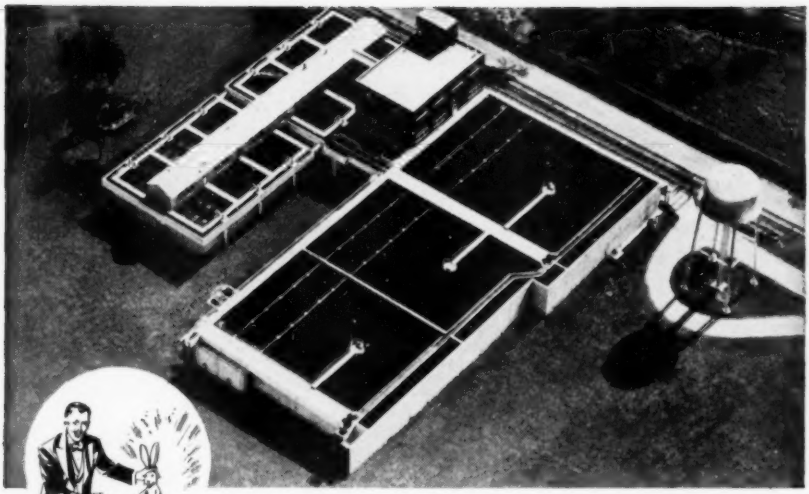

There's No "Magic Formula"

Every water treatment problem is different

No two water treatment problems are exactly alike. To get the best — and most economical — answer to your specific problem requires careful analysis of raw water composition, rate of flow and the results you require.

There *is* no magic formula . . . no single equipment unit that will give ideal results under all conditions. That's why it will pay you to check both conventional and high-rate units on every water treatment problem.

For a brief picture of the complete Dorr equipment line ask for Bulletin #9141. The Dorr Company, Stamford, Conn.

Repeat order in 1950 "proves out" a "conventional" installation made in 1948.

Quick facts about the Dorrco installation at the
Hollingsworth & Whitney Co., Chickasaw Mills, Mobile, Alabama

1948 . . . First order installed with a design capacity of 10 MGD: 2 Dorrco Flash Mixers, 1 Dorrco Flocculator, 1 Dorrco Squarex Clarifier, 85′ square.

Operating Results . . . Raw water: Color — 65-70 ppm, Raw water: Turbidity — 3.5-3.9 ppm, Finished water: Color — 3 ppm (Dosage in ppm: Alum 20, Soda Ash 15, Chlorine 3 to 5)

1950 . . . Second order installed with design capacity of 16 MGD (Total design capacity: 26 MGD): 1 Dorrco Flash Mixer, 2 Dorrco Flocculators, 2 Dorrco Squarex Clarifiers, 75′ square.

Flocculator and Squarex are trademarks of THE DORR COMPANY — Reg. U. S. Pat. Off.

Every day, nearly 8 billion gallons of water are treated by DORR equipment.

Better tools TODAY to meet tomorrow's demand

DORRCO

DORR

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Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking